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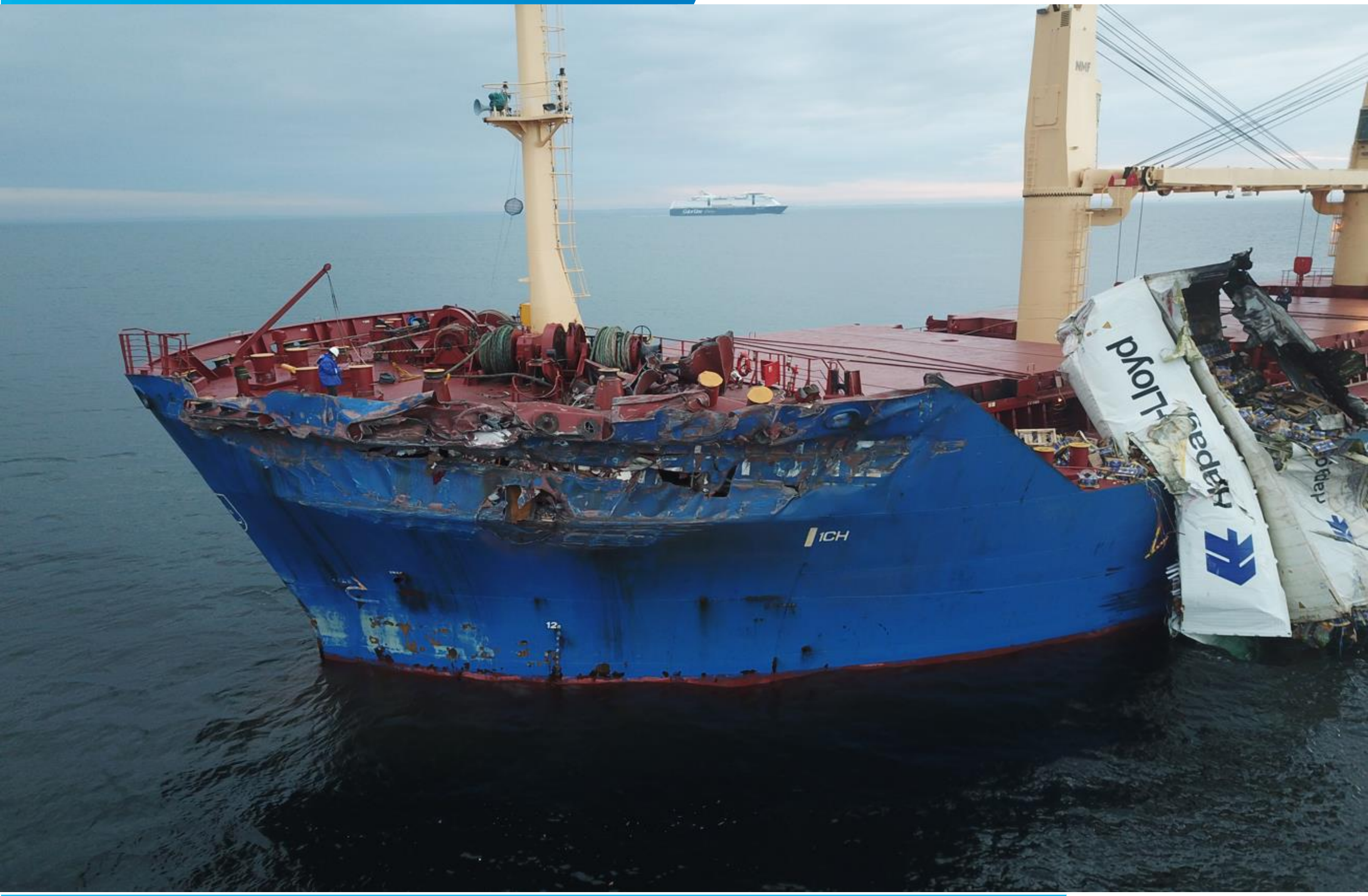

SAFETY ANALYSIS OF EMCIP DATA

ANALYSIS OF NAVIGATION ACCIDENTS

V1.0

September 2022

EMSA

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List of Abbreviations

AE	Accident event - is an event that is assessed to be inappropriate and significant in the sequence of events that led to the marine casualty or marine incident (e.g. human erroneous action, equipment failure)[1]
AIS	Automatic Identification System
ARPA	Automatic Radar Plotting Aid
AT	Action Taken - refers to any safety action that have been taken by a stakeholder to prevent marine casualties
AIB	Accident Investigative Body
AI Directive	Directive 2009/18/EC establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council
AoC	Area of Concern - are categories generated by homogenous contributing factors
BNWAS	Bridge Navigational Watch Alarm System
BRM	Bridge Resource Management
CE	Casualty Event. In the context of this analysis CE These are represents events which are the manifestation of the casualty based on the relevant taxonomy attributes in EMCIP (i.e. collision, grounding and contact). In this analysis, CE are based on the relevant EMCIP taxonomy.
CF(s)	Contributing Factor - is a condition that may have contributed to an accident event or worsened its consequence (e.g. man/machine interaction, inadequate illumination)1
CPP	Controllable Pitch propellers
ECS	Electronic Chart System
EEA	European Economic Area
ECDIS	Electronic Chart Display and Information System
ECFA	Event and Contributing Factors Analysis. It is a methodology used for analysing accidents by depicting the necessary and sufficient events and the contributing factors that led to the occurrence
EMCIP	European Marine Casualty Information Platform
EMSA	European Maritime Safety Agency
EU	European Union
GPS	Global Positioning System
LOA	Length Overall
MAS	Maritime Assistance Service
MS	Member States
Navigation accidents	In the context of this analysis, navigation accidents refer to reported occurrences with the following casualty events: collision, grounding or contact.
Occurrence	In the context of this analysis, occurrence refers to marine casualties and incidents
OMC	Other Marine Casualties. This category includes casualties with severity “serious” and “less serious”.
OOW	Officer of the Watch
OWS	Occurrence with ship. It indicates an unwanted event in which there was some kind of energy release with impact on people and/or ship and its cargo or environment (e.g. fire, collision, grounding etc)

[1] As defined in IMO A.28/Res.1075 dated 24/02/2014.

OWP	Occurrence with person(s). It indicates an unwanted event in which a person (crewmember, passenger or other person) resulted killed or injured. It includes the occupational accidents such as falling overboard, etc.
RADAR	Radio detection and ranging
SA	Safety Area, It is an area of interest identified on the basis of the EMCIP attributes *e.g*. vessel types or size, events which are the manifestation of the casualty (*i.e*. the casualty event), operational modes of the vessel, or any other attribute from the taxonomy provided that enough data is available for analysis
SI	Safety Issue. It is an issue that encompasses one or more contributing factors and/or other unsafe conditions[1]
SMM	Safety Management Manual
SMS	Safety Management System
SOP	Standard Operating Procedures
SR	Safety Recommendation - refers to any proposal made by AIB conducting the safety investigation on the basis of information derived from that investigation
TDMS	Traffic Density Maps Services
TSS	Traffic Separation Scheme

1. Executive summary

Figure 1 – Grounding of M/V "Rhodanus" in Corsica on 13/10/2019 – BEA Mer (France)

The European Maritime Safety Agency (EMSA) has developed a methodology to analyse the findings of the safety investigations reported in the European Marine Casualty Information Platform (EMCIP) to detect potential safety issues. This methodology assesses and identifies specific "core" attributes, like the accident events and the factors that led to the occurrences and has been applied to understand why navigation accidents (collisions, groundings and contacts) happen. The relevant dataset is composed by the occurrences reported in EMCIP by the EU-EEA Member States[2] between 2011 and 2021.

The analysis identified nine safety issues. Each of them has been further examined into 45 sub-categories named "areas of concern".

Following a further assessment based on frequency of reported contributing factors, the 5 most common safety issues related to navigation accidents are linked to: **(i)** Work operation methods, **(ii)** Organisational factors, **(iii)** Risk assessment, **(iv)** Environment, and **(v)** individual factors.

The analysis also considered the remedial actions suggested to prevent similar occurrences in future, either safety recommendations (SR) proposed by an Accident Investigative Body (AIB), or autonomously taken by the relevant parties (e.g., ship companies, maritime administrations, port authorities, *etc*…).

[2]The analysis encompasses a timeframe between 17/06/2011 (date of transposition of Directive 2009/18/EC by the EU Member States) and 31/12/2021.

AIBs issued most of their SR to the shipowners and companies (51.5%), mainly addressing operational procedures within the Safety Management System (SMS).

Other SR, addressed to the national authorities (around 22%), aimed at improving horizontal safety issues which appear common to the whole industry, thus requiring further discussions within international and EU frameworks.

Around 78% of the investigated navigation accidents is somehow linked to “human action”. The document goes beyond the face value of this figure and focuses on the complexity behind the human error, especially when the actions of the Master or OOW are scrutinised and demonstrates that the variability of the key actors’ performance is not the explanatory cause of the marine casualty. Conversely, human action is a consequence of the complex, non-linear and dynamic socio-technical interactions between humans onboard, organisations ashore, policies, procedures and machines.

The outcome of the analysis also puts other important topics in the limelight which, given their significance and complexity, could be the starting point to a process of a more formal and detailed approach on each of the areas of concern in the appropriate instances: coordination of the bridge team, workload and resource availability, conflicts generated by shipborne technology, bridge ergonomics and equipment design.

The key statistics based on factual information are included to provide a better understanding and contextualization of navigation accidents, either investigated or not.

Appendix A covers the methodology and the definitions used for these categories, while an overview of the EMCIP system is provided in Appendix B.

1.1 Acknowledgement

EMSA wishes to acknowledge the efforts by the AIBs of the EU Member States for reporting high-quality information in EMCIP, thus making possible conducting meaningful analysis of this data.

The Agency particularly thanks the Consultation Group composed by experts from the French Marine Casualties Investigation Board (BEAmer – France), the Federal Bureau for Maritime Casualty Investigation (BSU – Germany), the Danish Maritime Accident Investigation Board (DMAIB - Denmark), the Dutch Safety Board (DSB - the Netherlands), the Hellenic Bureau for Marine Casualties Investigation (HBMCI - Greece) and the Marine Safety Investigation Unit (MSIU - Malta) for their active contribution to this work.

1.2 Disclaimer

The marine casualty and incident data presented is strictly for information purposes only. The analysis presented in this document derives from the data that the AIBs of the Member States have reported in EMCIP. While every care has been taken in preparing the content of this report to avoid errors, EMSA does not guarantee the accuracy, completeness or recurrence of the statistics in the report. EMSA shall not be liable for any damages or other claims or demands incurred as a result of incorrect, insufficient or invalid data, or arising out of or in connection with the use, copying or display of the content, to the extent permitted by European and national laws. The information contained in the report should not be construed as legal advice.

2. Introduction

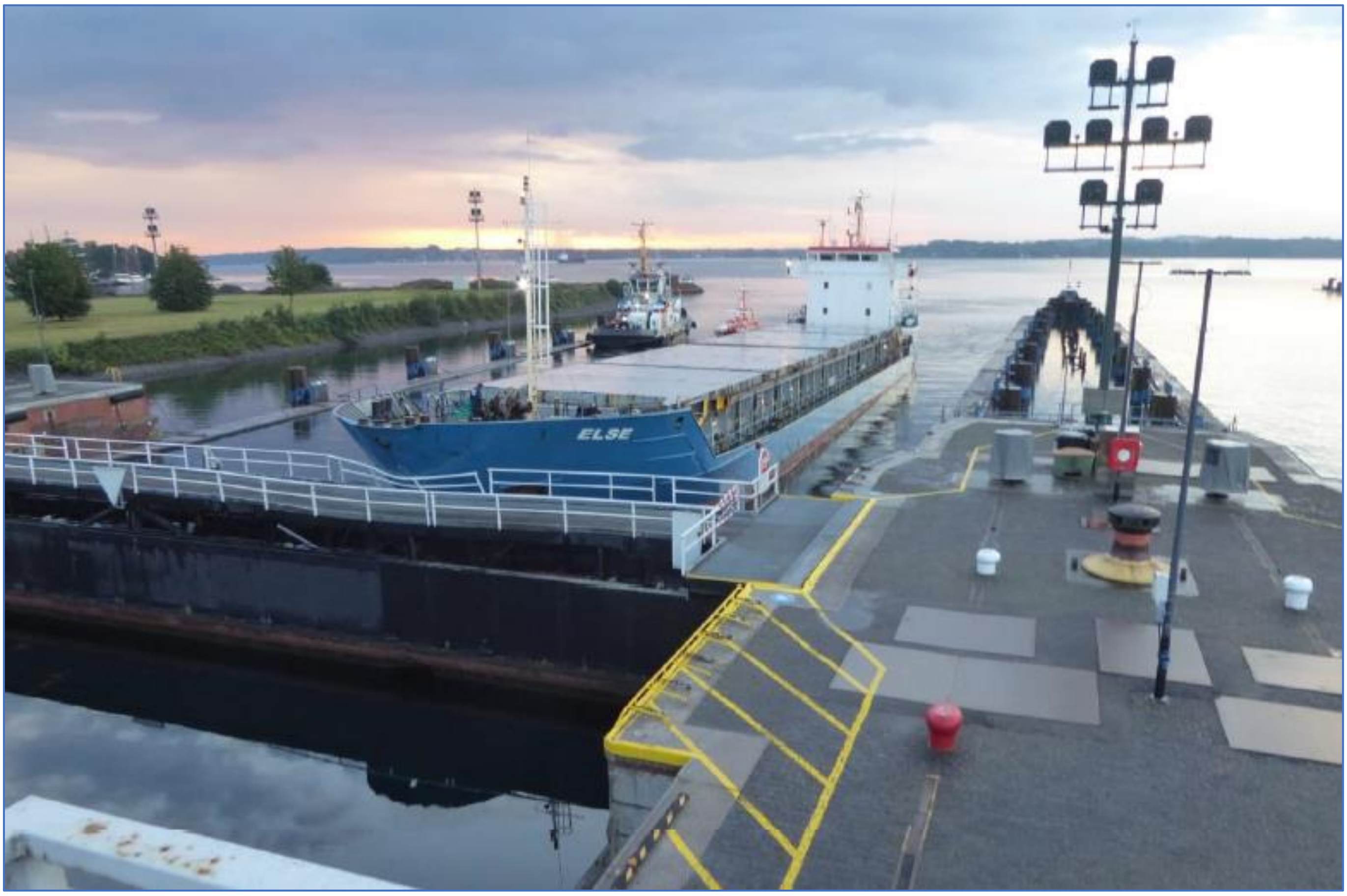

Figure 2 – Contact of M/V “Else” to the Kiel-Holtenau lock on 29/08/2020 – BSU (Germany)

2.1 Why navigation accidents?

This document presents the results of an analysis on navigation accidents reported in EMCIP, comprising collisions, groundings and contacts involving passenger ships, cargo vessels and service ships. Such marine casualties and incidents are widely reported in the system and are a source of concern for maritime safety[3].

The relevance of looking at navigation accidents is supported by the following rationale:

- The significant amount of reported occurrences in EMCIP, scoring around 28% of the overall dataset;
- The possibility to apply the EMSA methodology to detect safety issues on cases that are horizontal to different types of vessels;
- The public visibility of major navigation accidents. Notable examples include, amongst others, contact of “Nordlys” (15/09/2011), grounding of “Costa Concordia” (13/01/2012), collision between “Corvus J” and “Baltic Ace” (05/12/2012), collision between “Consouth” and “Pirireis” (29/04/2013), collision between “Ulysse” and “CSL Virginia” (07/10/2018) *etc*.

This analysis aims at providing possible trends based on factual information reported in EMCIP, analysing the safety issues and the proposed remedial actions following safety investigations, including the possible misuse of technology on the bridge, *e.g.* AIS data, radar, alarms, etc and illustrating lessons learned from the investigations.

[3] Occurrences involving only fishing vessels have been excluded since such a kind of ships had already been the subject of a comprehensive analysis (http://www.emsa.europa.eu/accident-investigation-publications/safety-analysis.html)

The “EMSA Single Programming Document 2022-2024” indicates as a strategic objective the analysis of casualty data and reports from safety investigations and the proposal, when relevant, of any appropriate Safety Recommendations to the Commission.

Moreover, other projects carried out by the Agency are likely to benefit from this report, for instance the MASS/RBAT initiatives[4].

2.2 The EU framework for Accident Investigation

Directive 2009/18/EC (AI Directive) was adopted to establish *“the fundamental principles governing the investigation of accidents in the maritime transport sector”* .Its purpose is “*to improve maritime safety and the prevention of pollution by ships, and so to reduce the risk of future marine casualties, by (a) facilitating the expeditious holding of safety investigations and proper analysis of marine casualties and incidents in order to determine their causes; and (b) ensuring the timely and accurate reporting of safety investigations and proposals for remedial action”*.[5]

The AI Directive lays down obligations regarding the organisation, conduct, reporting and undertaking of safety investigations on marine casualties and incidents by the Member States. It applies to:

- casualties involving ships flying a flag of one of the EU Member States; or
- those that occurred within a Member State’s territorial sea and internal waters as defined in UNCLOS[6]; or
- those involving other substantial interests of the Member States.

The AI Directive mandates each MS to establish an impartial and permanent AI body, with emphasis on the identification of possible safety recommendations to prevent similar accidents.

The AIB shall be an independent organisation, provided with sufficient resources, including trained and qualified investigators and enabled to respond immediately following the notification of a marine casualty or incident.

Safety investigations are conducted with the sole objective of preventing marine casualties and marine incidents in the future and, under no circumstances, they should determine liability or apportion blame.

The implementation of the AI Directive and its Common Methodology[7], in addition to the international legal framework[8], facilitates a harmonised approach across EU in conducting safety investigations, thus contributing to make the AIB community an asset for the safety of navigation.

Moreover, the establishment of EMCIP has increased the reporting of occurrences and facilitated the sharing of information.

The minimum data stored on EMCIP for each occurrence provides the factual information of the event and has to be reported in accordance with the mandatory notification data requested in Annex II of the AI Directive.

A complementary system’s taxonomy has been defined by EMSA, the European Commission and the MS to report, in a harmonized way, details derived by safety investigations, including the relevant findings stemming from the analysis process and a further input of the investigative bodies.

[4] Further details at http://emsa.europa.eu/mass.html
[5] Article 1.1 of the AI Directive.
[6] United Nations Convention on the Law of the Sea, 1982.
[7] Commission Regulation (EU) nr. 1286/2011.
[8] http://www.imo.org/en/OurWork/MSAS/Casualties/Pages/Applicable-IMO-instruments-on-casualty-matters.aspx

2.3 Finding potential safety issues through the analysis of EMCIP data

EMCIP provides the means to store data and information related to marine casualties and incidents involving all types of ships, including occupational accidents related to ship operations. It also enables the production of statistics and analysis of the technical, human, environmental and organisational factors involved in accidents at sea.

The system contains a large amount of notification and investigation data, reported by the EU MS in line with the reporting requirements stemming from the AI Directive. At the end of 2021, the database comprises around 31,300 notified occurrences, out of which, about 1,500 are investigations.

This information is a useful source of data to assess the qualitative and quantitative characteristics of casualty events, including the underlying factors of marine casualties and incidents.

The analysis has been conducted in line with the dedicated EMSA methodology, as detailed in appendix A, taking into account the following principles:

- potential safety issues[9] derived from a data-driven assessment; and,
- the EMCIP taxonomy was the primary tool for organising the information.

Within the scope and framework of the EMCIP Safety Analysis methodology, using the available data from investigated and non-investigated accidents stored in the system, it was possible to assess trends, safety issues and Areas of Concern (AoC) analytically with the view to identify which main factors contributed to the marine casualties and incidents.

Appendix B provides general information on EMCIP and the database model which is based on the Event and Contributing Factor Analysis (ECFA).

[9]Safety investigation reports and other sources have been used as complementary sources of intelligence when needed.

3. Statistics concerning navigation accidents

Figure 3 – Collision between LNG Carrier "Aseem" and VLCC "Shinyo Ocean" within the passage channel of the Fujairah Offshore Anchorage Area, UAE on 25/03/2019 – MSIU (Malta)

The figures included in this chapter cover collisions, groundings and contacts involving passenger vessels, cargo and service ships reported in almost 10 ½ years, between 17/06/2011-31/12/2021[10].

During that period, the EU-EEA MS reported in EMCIP 8,800 occurrences, a number of which have been investigated.

The reader should consider that some of the statistics in this chapter are based on non-mandatory attributes, while other figures derive from attributes supporting multiple values. Although some caution should be made when comparing figures across the various sections, the charts and tables provided are deemed to offer valuable additional context to the navigation accidents.

Further details on statistics and trends on marine accidents are regularly published by EMSA in the "Annual overview on marine casualties and incidents"[11].

[10] Date of extraction from EMCIP: 05 January 2022.
[11] Available at http://www.emsa.europa.eu/accident-investigation-publications/annual-overview.html

3.1 Occurrence severity

Of the occurrences analysed, 1.4% have been classified as "very serious" (VS), 79.6% as "other marine casualties" (OMC[12]) and 19% as "marine incidents" (MI).

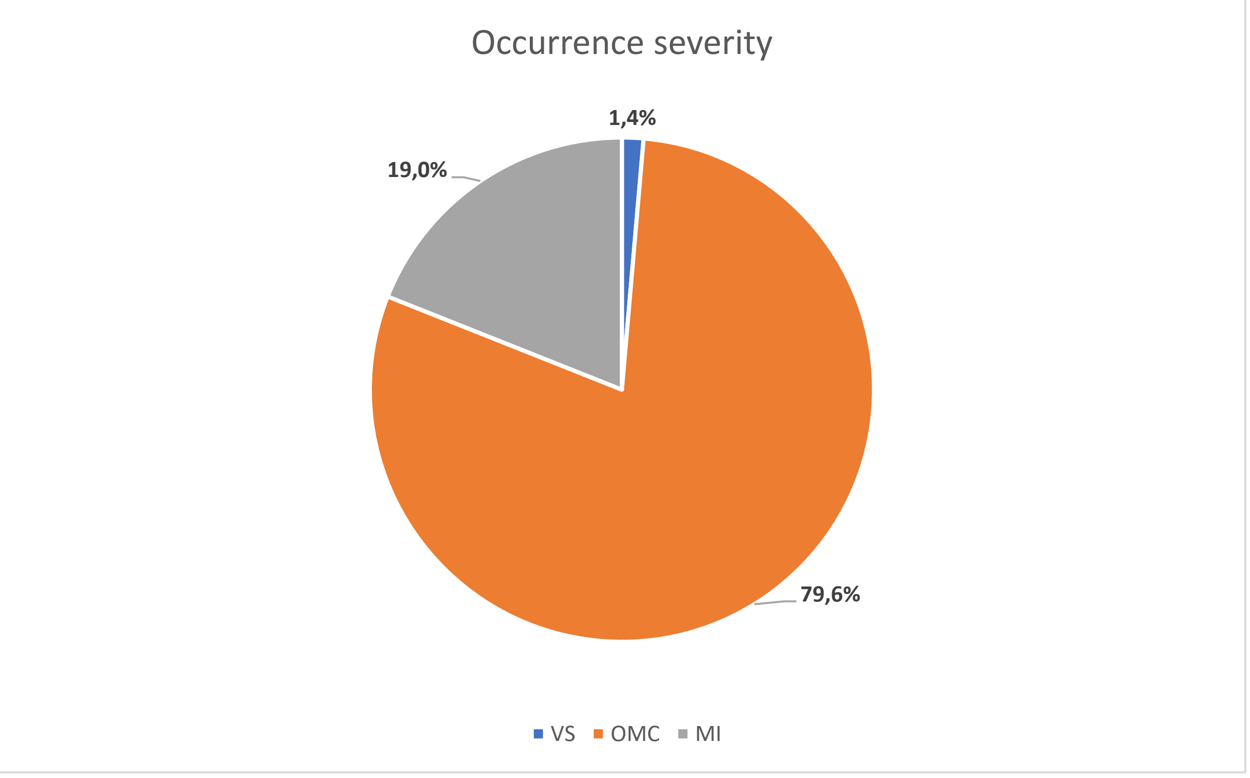

Table 1 - Occurrence severity

Data shows that "Very serious" peaked in 2014 and 2018, followed by a sharp decline starting from 2019.

OMC registered a sharp increase in 2013 (+71% compared with 2012), followed a stable trend until 2015 and, eventually, showed a general decrease.

Reported MI show a different path than VS and OMC. After a peak in 2012, MI registered a significant drop in 2013 and a relatively stable trend until 2016. After 2016, the number of MI significantly increased to reach another peak in 2018; then, the general tendency decreased.

3.2 Consequences to person

Figures in section concern people lost or injured resulting from navigation accidents with passenger, cargo and service ships. Figures are not necessarily linked to the people on board the ships at stake but may also refer to other types of vessels involved in navigation accidents with passenger, cargo and service ships. For instance, the chart below would also include the lost crew member of a fishing vessel following a collision with a container ship.

Navigation accidents involving passenger, cargo and service ships resulted in 173 fatalities and 719 injured persons for the period of the study.

[12] "OMC" encompasses the occurrences with severity "serious" and "less serious"

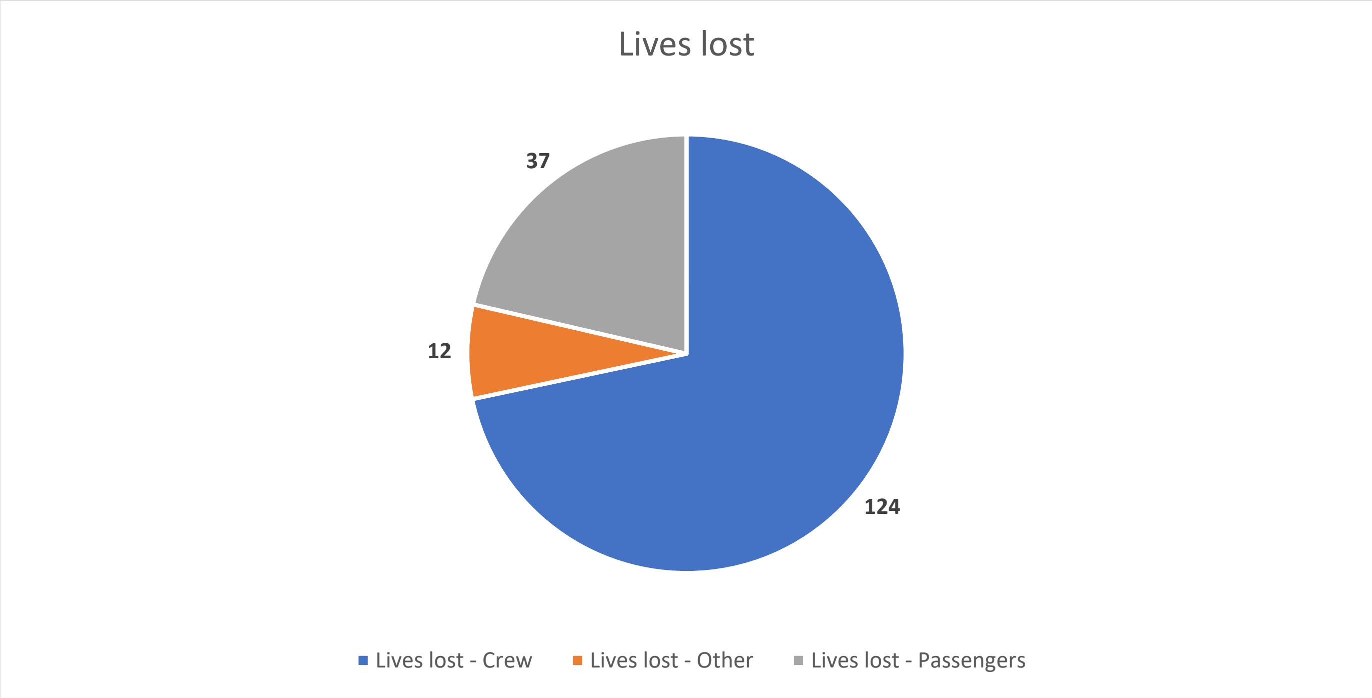

Figure 4 - Consequences to people (Lives lost)

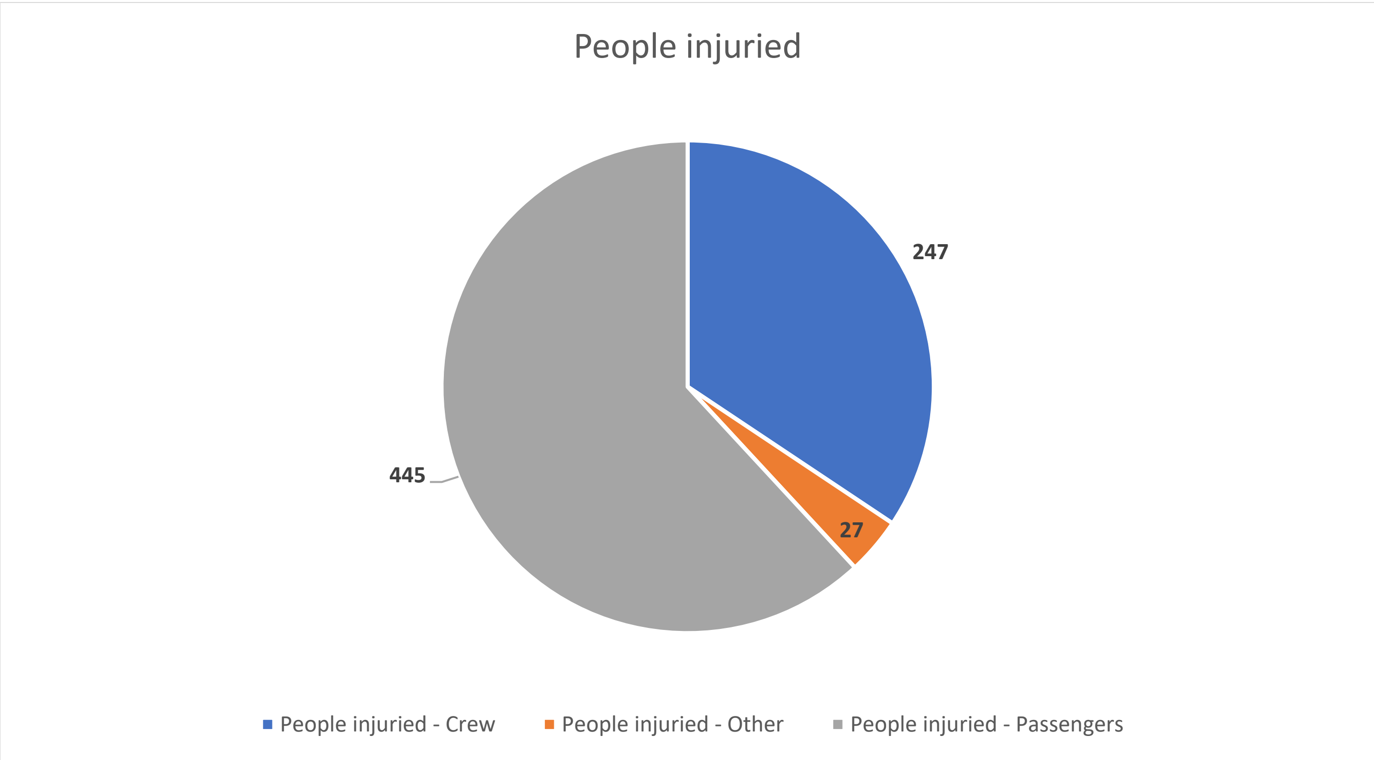

Figure 5 – Consequences to people (People injured)

Fatalities peaked in 2012 and 2016, when major accidents occurred: the “Costa Concordia” grounding (32 fatalities) and the collision between “Corvus J” and “Baltic Ace” (13 fatalities) in 2012; the collision of M/V “Catalina” and the fishing vessel “Lu Rong Yu 58398” (19 fatalities) in 2016.

The number of reported fatalities after 2016 is well below the average for the period at stake (17).

Injured [13]people reached the highest values in 2012, 2014 and 2017. The most significant occurrences in 2012 are the grounding of the passenger ship “Guillemot” (16 people injured), the already mentioned “Costa Concordia” event (17 injuries) and the contact of Ro-Ro Djurgården 11 with a quay (14 injuries). In 2014 the contact of the passenger ship “Adler Express” and the collision between the passenger ship "Stockholm Ström 2" and a tender boat registered respectively, 49 and 20 and people injured. In 2017, two hard contacts in port areas resulted in 37 and 29 injured people, respectively, on the ferry “Antero de Quental” and the passenger ship “Maria Buono”.

Injuries dropped down consistently after 2017 and, especially, after 2019.

3.3 Vessels involved

More than 10,500 vessels were involved in navigation accidents. Out of these, 61.5% were cargo ships, 22.3% passenger ships and 16.2% service ships.

Type of ships	Nr.	%
Cargo ship - Solid Cargo	5,160	48.8%
Cargo ship - Tanker	1,319	12.5%
Passenger ship - Only passenger	1,143	10.8%
Passenger ship - Passenger and cargo	1,212	11.5%
Service ship	1,710	16.2%
Cargo ship - Not specified	27	0.3%
Total	**10,571**	**100.0%**

Table 2 - Type of vessels involved in navigation accidents

3.4 Consequences to vessels

3.4.1 Loss/damage to ship or equipment

Reported data concerning the type of damage to ships indicates that around 45% of the ships involved in navigation accidents did not report damages, while 43.4% experienced material damage, either affecting the ship's structural integrity or the ship’s operational characteristics. Less than 10% reported light consequences not configurable as material damage[14]. Ships lost count 0.6% of the total.

Loss/damage to ship or equipment	Nr	%
No damage	4,044	45.7%
Material damage – Not specified	3,424	38.7%
Minor damage (less than material damage)	858	9.7%
Material damage - Affecting structural integrity of the ship	258	2.9%
Material damage - Affecting performance or operational characteristics of the ship	158	1.8%
Material damage - Affecting marine infrastructure or other ship	57	0.6%
Loss of ship - Actual loss	32	0.4%
Loss of ship - Constructive loss	14	0.2%
Total	**8,845**	**100.0%**

Table 3 - distribution of loss/damage to ship or equipment

[13] Injuries as reported in EMCIP are not further classified to serious or non-serious as per IMO CIC provisions (Ch.2.18 of Part I of Res. MSC.255(84))
[14] “Material damage” is defined in Ch.2.16 of the IMO CIC (you may include full text definition if deemed necessary)

3.4.2 Unfit to proceed

IMO legislation[15]considers the ship "unfit to proceed" when she is *"in a condition, which does not correspond substantially with the applicable conventions, presenting a danger to the ship and the persons on board or an unreasonable threat of harm to the marine environment".*

The analysis has shown that 902 vessels under the scope of this analysis resulted unfit to proceed following navigation accidents.

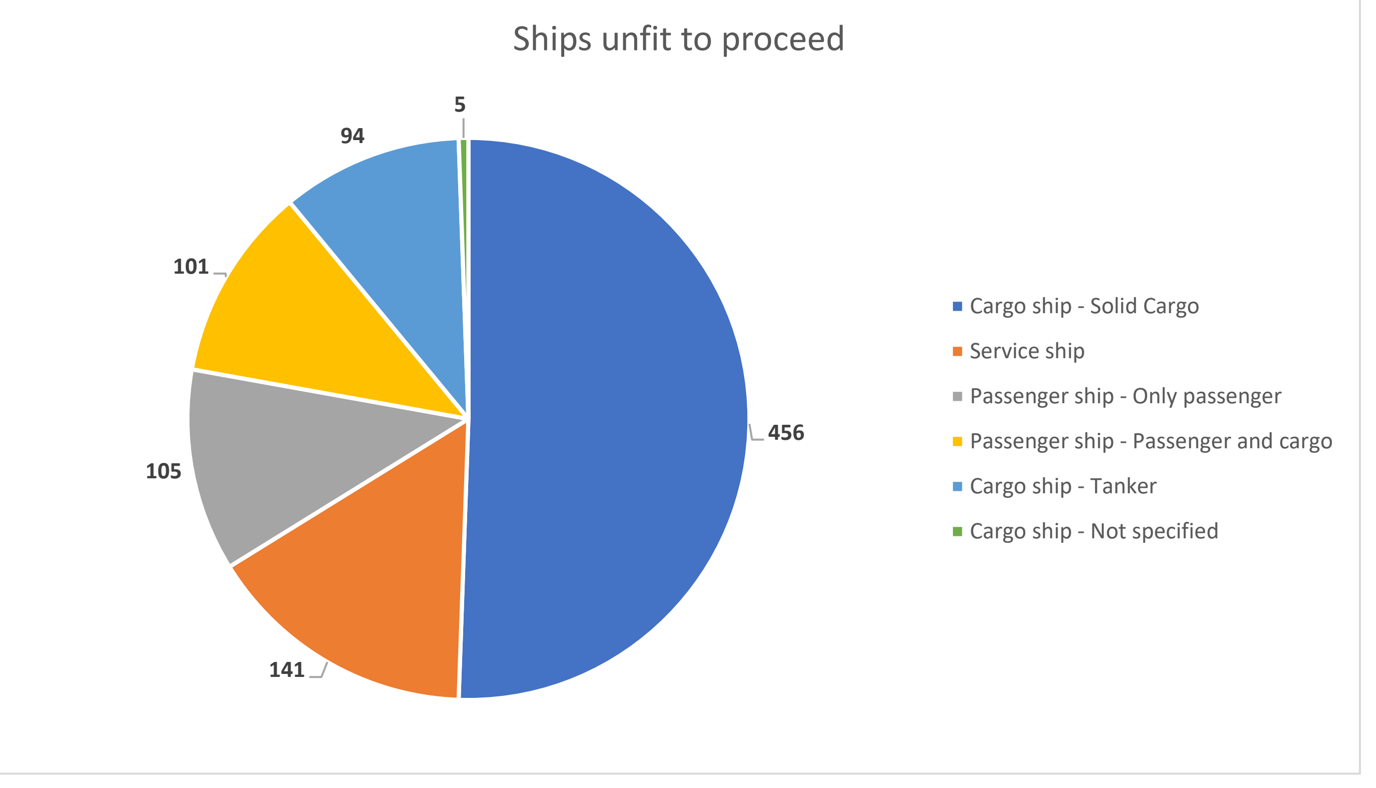

Figure 6 - Ships unfit to proceed

More than 50% of the ships reported unfit to proceed belongs to the category "Cargo ships -Solid cargo" (456 ships).

[15] MSC-MEPC.3/Circ.3, 18 Dec 2008

3.5 Type of casualty events

3.5.1 Navigation accident distribution

Within the timeframe of the analysis, 8,847 casualty events classified as navigation accidents have been reported in EMCIP[16]. Around 41% of such events concerns contact, 30 losses of control/containments, collisions and contacts.

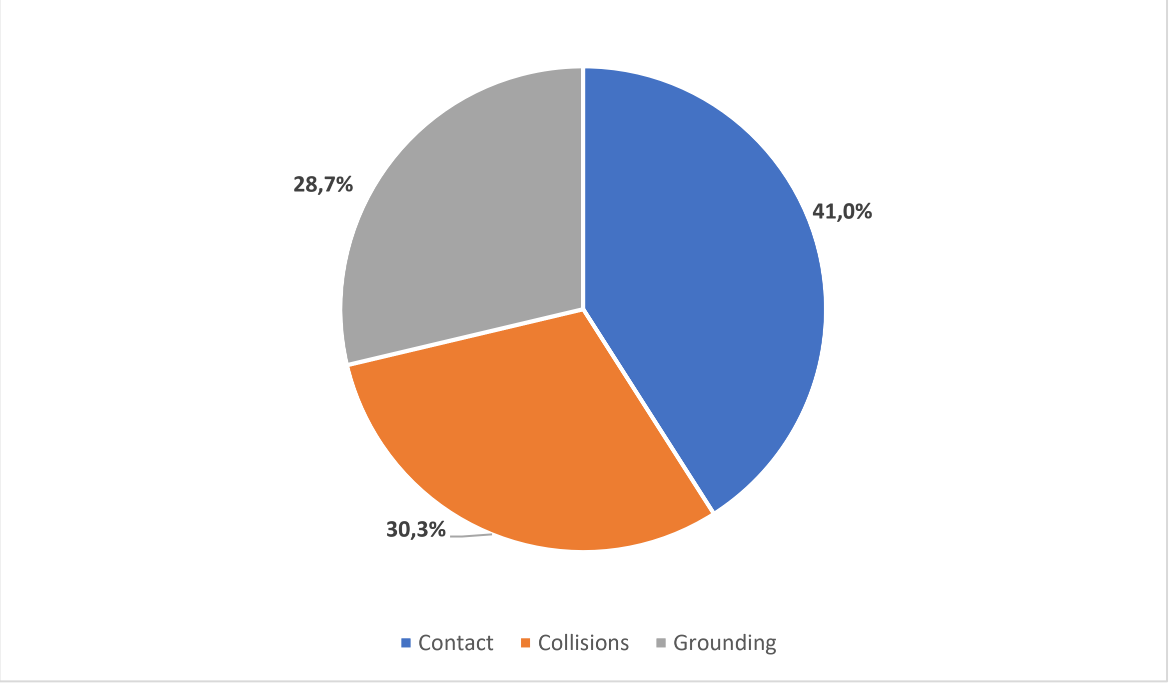

Table 4 - Occurrence with ship (distribution)

3.5.2 Navigation accidents linked to other casualty events

Each reported occurrence may envisage one single event or multiple, depending how the accident event dynamics unfold. For instance, a loss of propulsion power deriving from a failure in the main engine may lead to a grounding and to a subsequent flooding.

Data reported in EMCIP indicates that 3.7% of the occurrences involving navigation accidents are linked to other types of casualty events.

[16] Collisions have been counted as a single CE

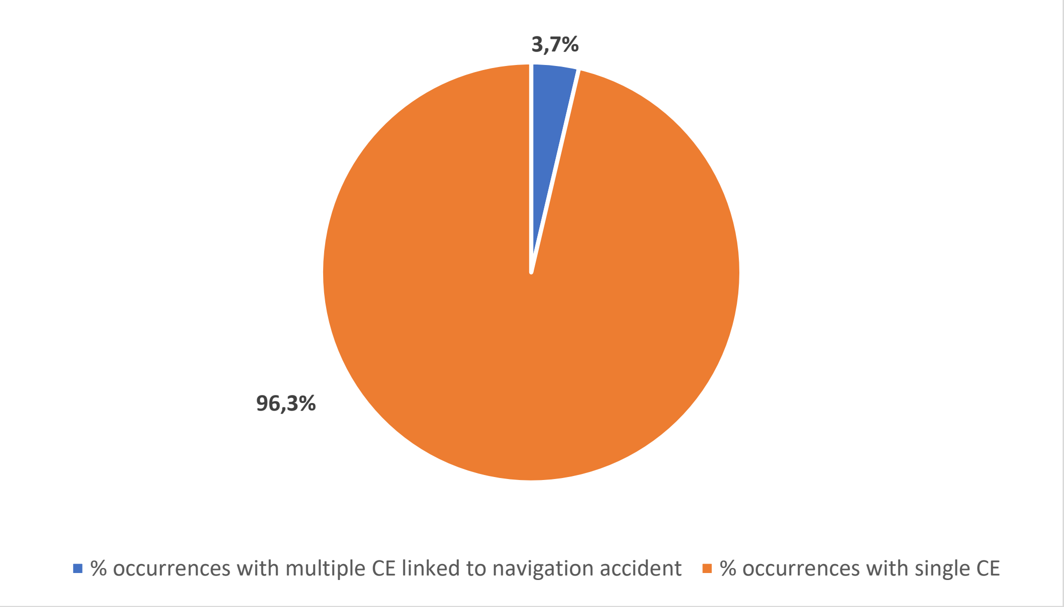

Table 5 - Distribution of the occurrences based on the nr. of associated CE

3.6 Sea area

3.6.1 Distribution by sea area

As presented in the following chart, navigation accidents had mainly occurred in the port areas (54%) and the territorial sea (19.1%). Around 17% occurred in other internal waters (*e.g.* rivers, archipelago fairways, channels etc.), 4.5% in open sea (either in or outside EEZ) and around the same in inland waters.

The remaining categories "repair yard" and "unknown" reach overall a residual 0.6%. It should be noted that in some MS the accidents to a ship during her stay in a repair yard are not considered as relevant to the ships operations, thus not considered under the scope of the AID.

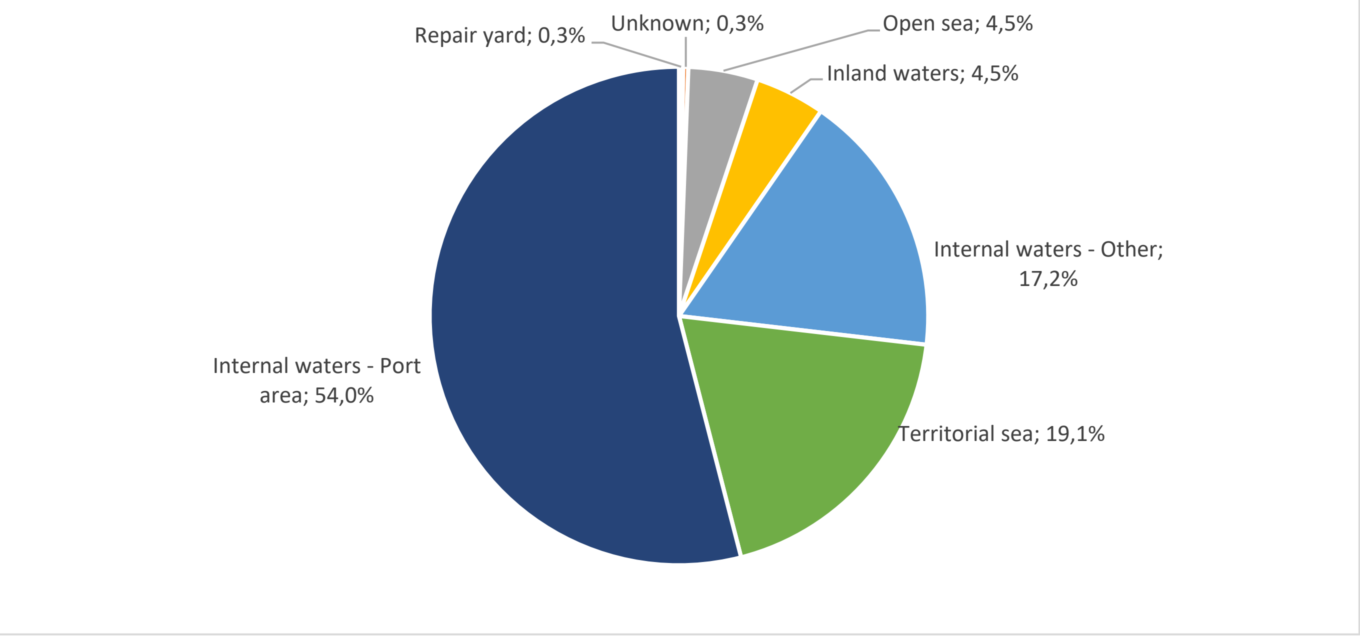

Figure 7 - % distribution of casualty by sea area

The fact that most of the navigation accident occurred within port areas and territorial sea is not surprising due to the higher traffic density inbound/outbound harbours, the presence of shallow waters impacting on grounding and other shore objects, like the port infrastructures, and the expected increase in cognitive workload on the OOW and the bridge team. Such elements had an impact on collisions, groundings and contacts, as demonstrated in the next chapters.

A better depiction of the geographic distribution of navigation accidents and traffic density can be found below.

The first set of charts (heatmaps) indicate the areas with the higher frequency distribution of navigation accidents reported in EMCIP. Heatmaps provide a qualitative representation of the accident distribution based on the associated colour: 

The second set shows the geographic correlation between the reported navigation accidents and the TDM[17], which provide vessel traffic density maps generated by the EMSA systems.

[17] The TDM are produced by compiling ship's AIS positioning data and can highlight the presence of congested areas.

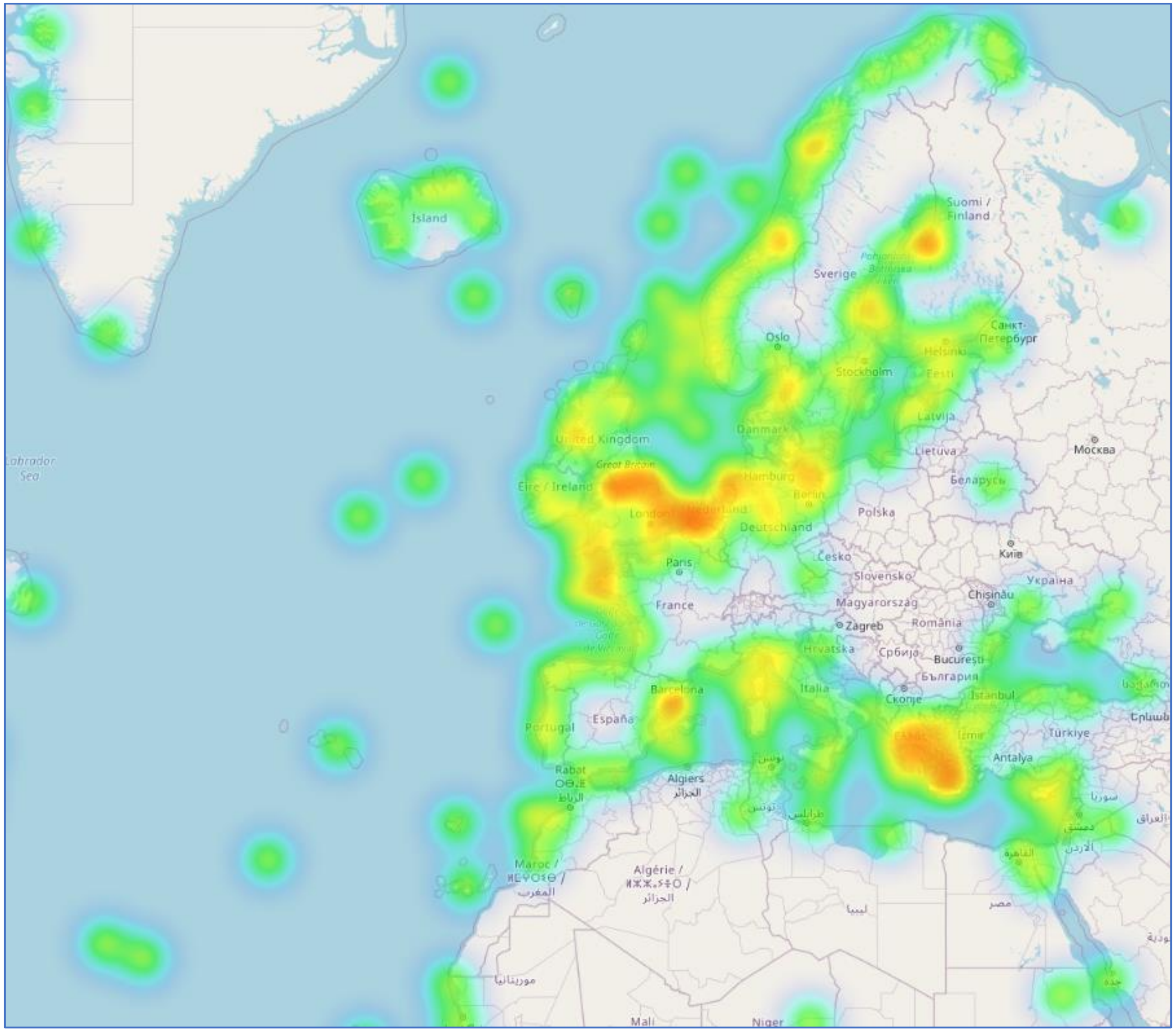

Figure 8 – Heatmap of navigation accidents (focus on waters surrounding EU-EEA MS)

European Maritime Safety Agency

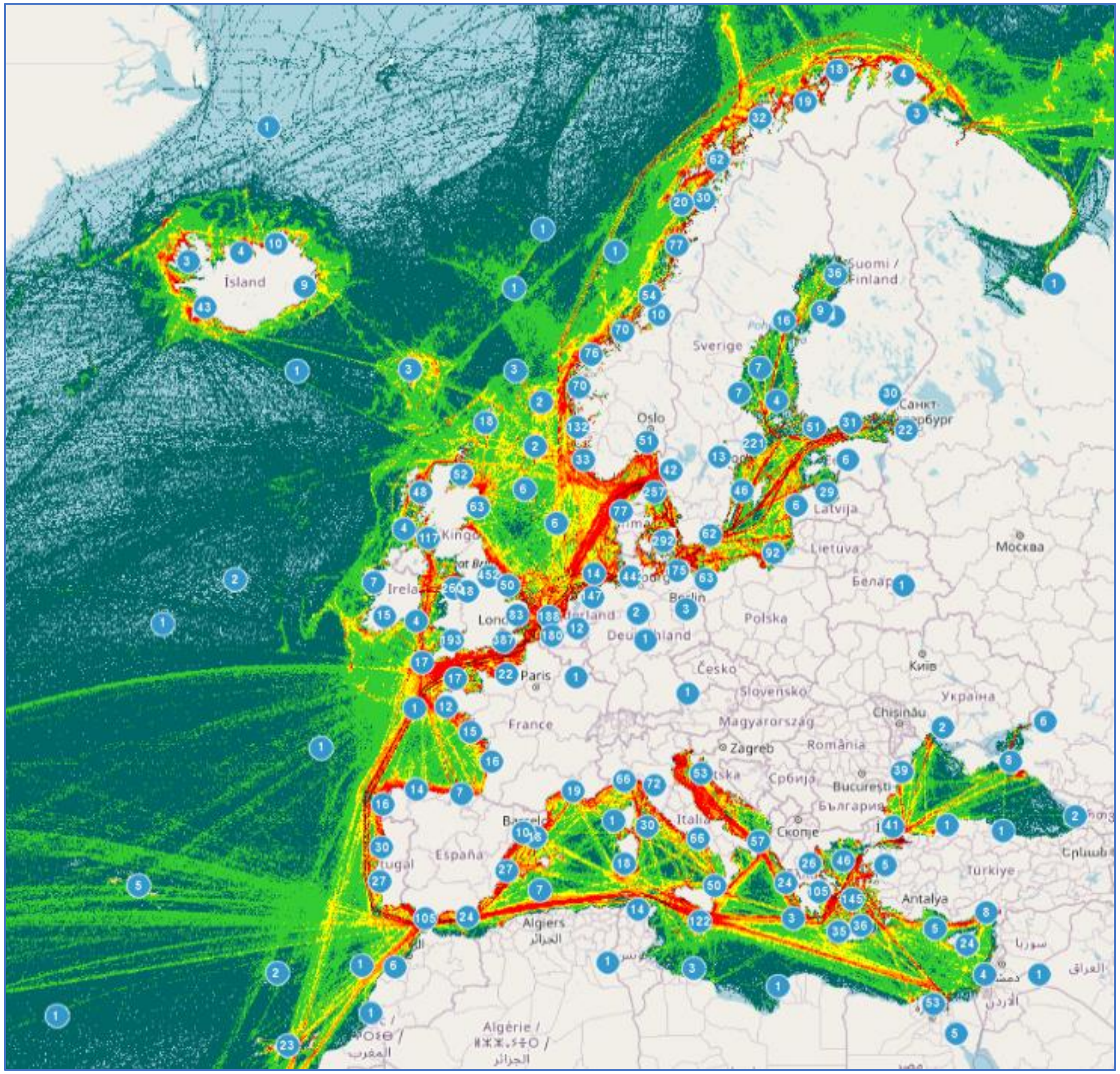

Figure 9 - TDM and distribution of navigation accidents (focus on waters surrounding EU-EEA MS)

Overlapping the TDM generated with the AIS traffic data collected in 2021 shows, unsurprisingly, that navigation accidents mainly occur in congested areas and, particularly, in chokepoints and nearby the major ports.

3.7 Ship operations

Collisions and groundings mainly occurred when the ships were in passage (2,973 overall) or manoeuvring/turning (3,108 overall), while it was found that manoeuvring/turning was the most frequent operation for contact (1,575). A significant number of collisions occurred in port areas between inbound/outbound vessels and ships moored (711).

Ship operation	Collision	Contact	Grounding	Grand Total
Alongside/Moored	711	171	78	960
Anchoring/At anchor	238	53	70	361
Ballasting	3		4	7
Berthing	2	4	3	9
Berthing/Unberthing	249	826	102	1,177
Bunkering	64	7	7	78
Cleaning/washing		1	1	2
Embarking/disembarking people	26	6	4	36
Emergency		2	2	4
Fishing	3	1	6	10
In passage	993	764	1,216	2,973
Loading/Unloading	55	21	17	93
Maintenance/Repairing	13	15	4	32
Manoeuvring/Turning	812	1,575	721	3,108
Normal service - Other	23	16	36	75
Open/close door; hatches; etc.		1		1
Other	68	25	42	135
Sailing	17	2	37	56
Special service - Dredging	38	27	12	77
Special service - Drilling	1			1
Special service - Other	73	31	30	134
Special service - Towing/Pushing	163	70	43	276
Special service - Windfarm operation	1	4		5
Starting/stopping engine	1	9	1	11
Under pilotage	276	491	299	1,066
Unknown	281	154	73	508
Total	**4,111**	**4,276**	**2,808**	**11,195**

Table 6 - Distribution per ship operation[18]

[18] The attribute “Ship operation” allows reporting multiple values for each ship involved.

3.8 Time of accident

The local time of the accident is an essential element as it indicates whether the occurrence took place during the day or night. It does not only help to understand the light conditions, which influence the visibility, but also contributes to contextualising the working setup onboard the ships, which could be significant for navigation accidents. For instance, the composition of the bridge team varies typically during the night-time which may be considered as resting period for most of the crew. Moreover, during the night-time other factors could play a significant role in contributing to navigation accidents such as boredom, tiredness, circadian rhythm etc.

The following tables correlate the time of the accident to the sea area of occurrence for collisions, groundings and contacts. The attribute "Time of occurrence" has been considered multiple times for the occurrences including multiple events, *e.g.* if 1 grounding and 1 contact were reported for the same occurrence.

3.8.1 Collisions

The distribution of collisions varies depending on the time and the sea area of occurrence. The table suggests that most of the collisions in port areas had occurred during the daytime, probably due to the ports' working time, which is typically more operational during the day. The time variance is less pronounced for the collisions reported in the territorial sea. Interestingly, the collision distribution in the open sea seems higher during the night-time, particularly between 00:00 and 06:00, when around 43% of the overall collisions in the open sea took place.

Time of accident (local time)	Inland waters	Internal waters - Other	Internal waters - Port area	Open sea	Repair yard	Territorial sea	Total
00	3	12	39	16		26	96
01	5	9	42	14	1	22	93
02	3	6	28	16		31	84
03	7	12	23	20		25	87
04	2	5	25	14	1	31	78
05	4	16	33	17		18	88
06	6	12	42	14		38	112
07	3	8	56	10		23	100
08	3	9	56	5	1	35	109
09	4	10	77	11	3	21	126
10	2	15	77	6		37	137
11	4	8	68	11	1	24	116
12	4	13	96	9		31	153
13	5	17	77	10	1	27	137
14	4	20	93	15		21	153
15	5	21	64	10		35	135
16	10	13	74	3	1	28	129
17	6	19	70	8		26	129
18	5	12	61	8		27	113
19	9	17	61	8	2	27	124
20	6	14	44	13		26	103
21	4	12	42	6		26	90
22	4	19	41	9		24	97
23	2	7	47	7	1	27	91
Total	110	306	1336	260	12	656	2,680

Table 7 - Link between time and sea area of occurrence (Collision)

3.8.2 Contacts

Overall, contacts appear more frequently in port areas during the daytime, possibly linked to the port operations which are typically higher during the daytime.

Time of accident (local time)	Inland waters	Internal waters - Other	Internal waters - Port area	Open sea	Repair yard	Territorial sea	Total
00	6	23	102	2		6	139
01	4	22	93	6		4	129
02	7	19	42	4		7	79
03	2	23	54	1		1	81
04		17	53	1		9	80
05	2	21	71	1		2	97
06	3	19	121	4		8	155
07	5	17	102	4		12	140
08	4	25	133	6	1	17	186
09	6	25	143	5	1	7	187
10	5	19	132	4	1	15	176
11	6	23	126	5	2	13	175
12	6	38	200	6		20	270
13	5	19	149	5		14	192
14	3	17	143	2		15	180
15	6	22	132	2	2	12	176
16	1	25	136	4	1	11	178
17	4	35	133		1	9	182
18	6	32	121			13	172
19	5	28	117	3		5	158
20	2	18	104			8	132
21	5	18	82	2		13	120
22	5	16	102	4		11	138
23	4	21	62	1		11	99
Total	102	542	2653	72	9	243	3,621

Table 8 - Link between time and sea area of occurrence (Contacts)

3.8.3 Groundings

Groundings in port areas are more frequent during the daytime, possibly due to the already mentioned reasons linked to the port operations. Data indicates that the variance of such events in the territorial sea and other internal waters is more regularly distributed between day and night.

Time of accident (local time)	Inland waters	Internal waters - Other	Internal waters - Port area	Open sea	Repair yard	Territorial sea	Total
00	6	26	25	3		24	84
01	9	17	23	6	1	30	86
02	3	14	18	1		31	67
03	3	23	22	2		22	72
04	4	21	19	3		33	80
05	6	32	29			31	98
06	9	26	38	2		32	107
07	11	36	36	6		39	128
08	4	24	43	4	1	34	110
09	12	36	50			34	132
10	13	33	44			38	128
11	4	32	35	4		35	110
12	11	35	50	5		41	142
13	6	28	41	4		36	115
14	7	31	45	2		34	119
15	9	33	38	6		42	128
16	13	24	33	8		26	104
17	12	24	41	4		38	119
18	6	38	46	3		42	135
19	6	30	24	3		31	94
20	12	26	33		1	31	103
21	12	32	38	1		26	109
22	8	22	20	2		33	85
23	3	28	21	1		28	81
Total	189	671	812	70	3	791	2,536

Table 9 - Link between time and sea area of occurrence (Groundings)

3.9 Safety investigations

Of 8,800 occurrences involving navigation accident, 370 cases were finished and ongoing safety investigations with a reported dataset suitable for further analysis. The highest proportion of those investigated include collisions (almost 44%), then groundings (38%) and finally contacts (18%).

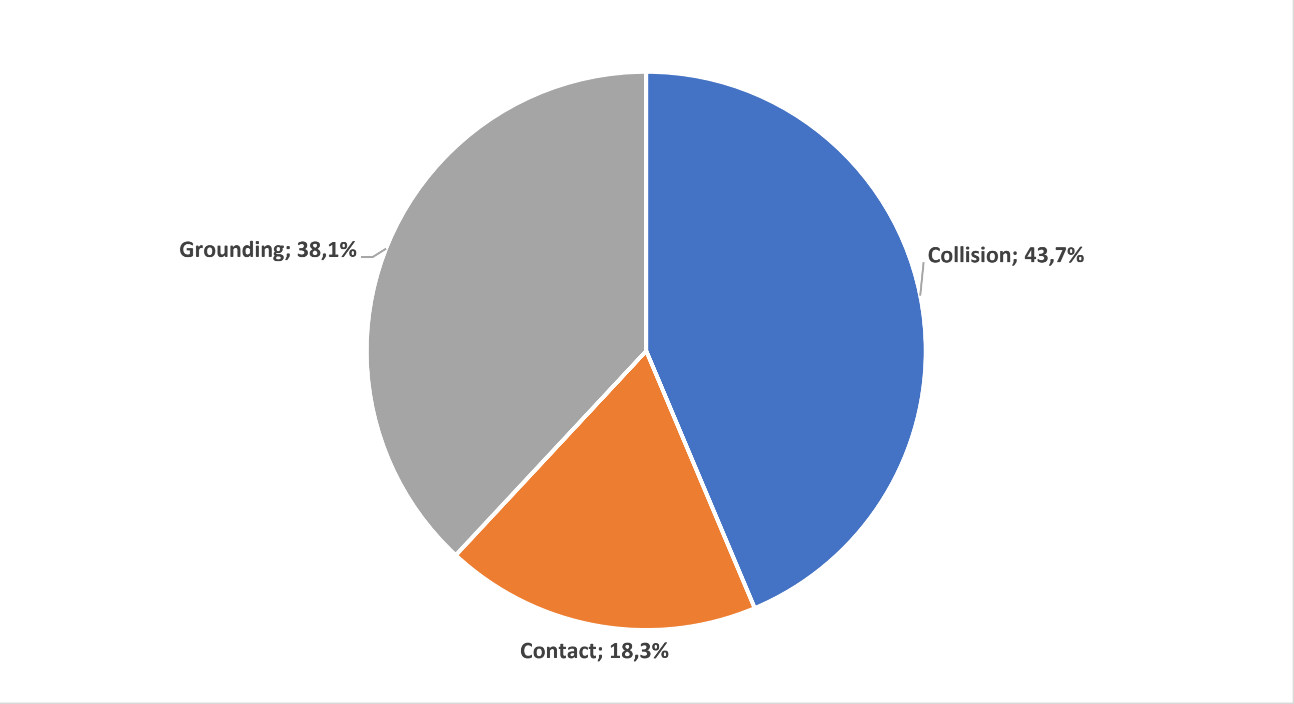

Table 10 - Navigation accidents dealt by safety investigations

The chart below shows the percentage of investigations carried out depending on the severity of the occurrence. These are characterised in Very Serious (VS), Other Marine Casualties (OMC, including serious and less serious marine casualties) and Marine Incidents (MI):

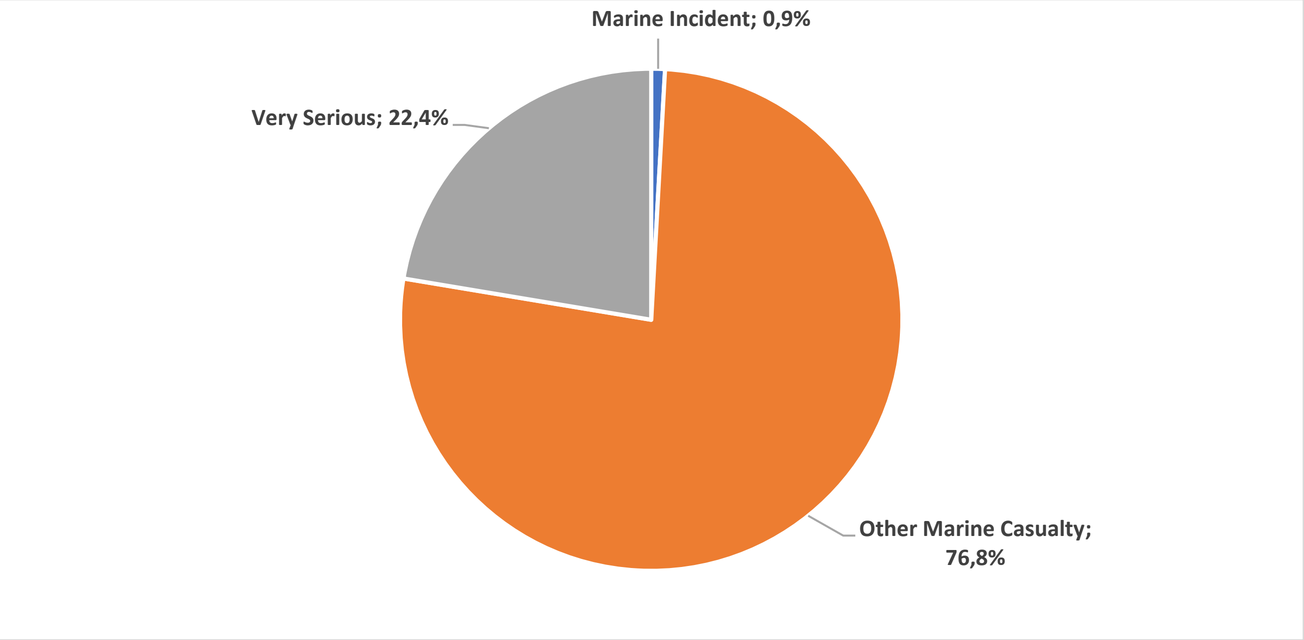

Figure 10 – Proportion of investigations per occurrence severity

So far, the analysis contextualises the navigation accidents by looking at the factual information reported in all the relevant occurrences.

The next chapters will attempt to answer why navigation accidents occur. The focus will be on the key elements of the safety investigations reported in the system, namely accident events, contributing factors, safety recommendations, and actions taken.

4. Accident events and human action

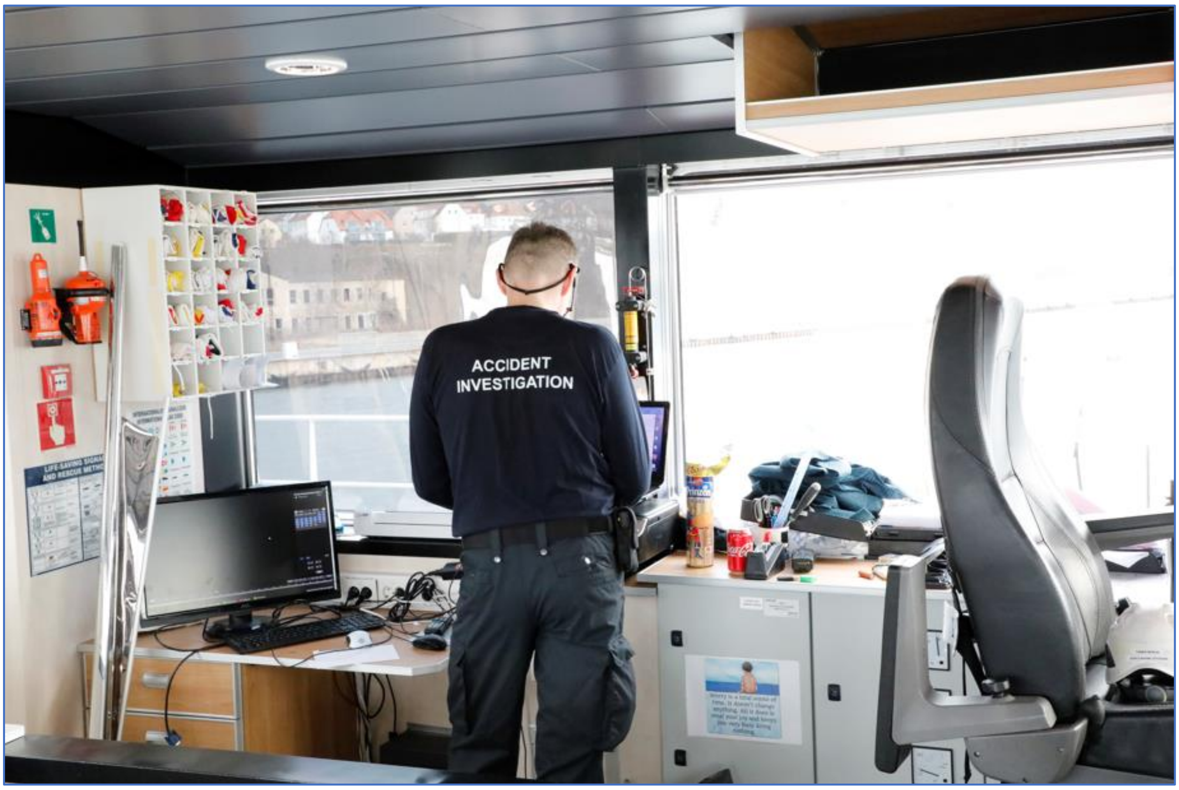

Figure 11 – Evidence gathering following a collision between commercial vessels – DMAIB (Denmark)

Evidence shows that very seldom a marine casualty is determined by a single cause. Conversely, safety investigations demonstrate that casualties are generally complex socio-technical occurrences characterised by mutual interdependence.

In the analysis phase, safety investigators look for the factors contributing to marine casualties and incidents. The ECFA model, albeit linear and focused on the event chain, is a narrative approach supporting structuring the investigation findings in a simple fashion; thus, it can be a complementary tool to more complex systemic analyses methods. In short, ECFA links casualty events to accident events and contributing factors.

Each marine casualty can have one or more casualty events, like contact, grounding, collision *etc*. For instance, contact with a submerged obstacle may lead to flooding and, eventually, grounding.

In the events' dynamics, it is important to distinguish "casualty events" from "accident events". The latter indicate inappropriate and significant events leading to the casualty event. In the above example, for instance, the contact with the submerged obstacle (the "casualty event") could have been preceded by the failure of the echo sounder (the "accident event"). In the EMCIP schema, each casualty event can be associated with one or more accident events.

Furthermore, each accident event may be linked to one or more contributing factors that explain the various underlining factors of the event. In the above example, the failure of the echo sounder may derive from undetected issues resulting from the inadequate maintenance policy of the Company and by the fact that the OOW cannot easily reach it due to its physical position on the bridge.

What is the difference between “accident event” and “contributing factor”? The former describes an occurrence or happening; thus, in principle can be labelled with a date and time (*e.g.* an equipment breakdown). The latter indicates underlining conditions, states or circumstances (*e.g.* the metal’s corrosion that led to the equipment to fail or the improper implementation of maintenance).

This level of analysis considered 351 safety investigations encoded in EMCIP by the AIB.

EMCIP taxonomy envisages five accident events types: “human action” (addressing human performance, action or omission), “system or equipment failure”, “other agent or vessel”, “hazardous material” and “unknown”.

The data presented from now onwards derives from the occurrences reported in EMCIP that have been investigated.

The table below shows that 573 accident events have been directly associated to navigation accidents. **Human action is, by far, the most reported category** (447 events).

Accident Event Type	Nr.	%
Human action	**447**	**78.0%**
Collision	212	37.0%
Grounding	172	30.0%
Contact	63	11.0%
Other agent or vessel	**78**	**13.6%**
Grounding	36	6.3%
Collision	28	4.9%
Contact	14	2.4%
System/ equipment failure	**44**	**7.7%**
Grounding	21	3.7%
Collision	12	2.1%
Contact	11	1.9%
Unknown	**4**	**0.7%**
Collision	2	0.3%
Grounding	1	0.2%
Contact	1	0.2%
Total	**573**	**100.0%**

Table 11 - Accident event directly associated to navigation accidents

Although “human action” scores around 78% of the overall reported accident event, its distribution is slightly different depending on the casualty event at stake:

Casualty Events	Nr.	%
Collision	**254**	**44.3%**
Human action	212	83.5%
Other agent or vessel	28	11.0%
System/ equipment failure	12	4.7%
Unknown	2	0.8%
Grounding	**230**	**40.1%**
Human action	172	74.8%
Other agent or vessel	36	15.7%
System/ equipment failure	21	9.1%
Unknown	1	0.4%
Contact	**89**	**15.5%**
Human action	63	70.8%
Other agent or vessel	14	15.7%
System/ equipment failure	11	12.4%
Unknown	1	1.1%
Total	**573**	**100.0%**

Table 12 - Accident events directly associated to navigation accidents - Distribution per casualty event

“Human action” counts 83.5% of the accident events reported for “collisions”, around 75% for “grounding” and around 71% for “contacts”.

"Other agent or vessel" refers to events associated with *e.g.* weather conditions or interactions with other ships. In proportion, it appears more significant for "contacts" and "grounding" (around 15.7%) than collisions (11%).

"System/ equipment failure" appears relevant for "contact" (12.4%) and less important for "collisions" and "grounding".

Several occurrences with "collision", "grounding" and "contact" also comprise other types of casualty events like "loss of control", "flooding", "Damage/ loss of equipment", "Capsizing", "Hull failure" and "fire" that the reporting AIB considered as relevant in the chain of the event leading to navigation accidents. An example is the loss of propulsion due to the main engine failure (casualty event "loss of control") that leads to the impact with the breakwaters (casualty event "contact").

These casualty events may be linked to one or more accident events. One hundred twenty-nine additional accident events have been associated with casualty events other than navigation accidents. Given their high informative value, the accident events linked to these additional casualty events have been considered in this document as "accident events indirectly associated to navigation accidents".

It is interesting to note that "system/equipment failure" is the accident events more frequently associated with these casualty events (56.6%), mostly "loss of control", followed by "human action" (28%).

Accident Event Type	Nr.	%
System/ equipment failure	**73**	**56.6%**
Loss of control	53	41.1%
Flooding	10	7.8%
Damage / loss of equipment	9	7.0%
Hull failure	1	0.8%
Human action	**36**	**27.9%**
Loss of control	27	20.9%
Capsizing	6	4.7%
Flooding	3	2.3%
Other agent or vessel	**14**	**10.9%**
Loss of control	8	6.2%
Damage / loss of equipment	4	3.1%
Flooding	2	1.6%
Unknown	**4**	**3.1%**
Loss of control	3	2.3%
Flooding	1	0.8%
Hazardous material	**2**	**1.6%**
Hull failure	1	0.8%
Fire	1	0.8%
Total	**129**	**100.0%**

Table 13 - Accident events indirectly associated to navigation accidents

The next sections further analyse the accident event "human action". Given its importance in the chain of events, all the "human action" events have been considered, directly and indirectly, associated with navigation accidents.

4.1.1 Human action: an introduction

The accident event "Human action" is instrumental in reporting human performance in EMCIP, which implements an approach based on the CREAM model.

When investigating casualties and incidents, the goal (and the challenge) is to determine how people's assessments and actions made sense at that time, given the circumstances surrounding them[19]. Therefore, the contemporary safety investigation process considers the detection of "human action" – as referred in CREAM, intended as performance variability of a person undertaking a given task (*e.g.* usage of RADAR, awareness *etc*.), as the starting point of an investigation, not its conclusion.

In this context, the term "human action" should not be understood to blame a person, but as a cognitive variability and represents the initial step of the wider analysis of the "human factors" involved in a marine casualty. Indeed, it is widely accepted by the EU AIB community[20] that the mere identification of human errors cannot explain alone why the marine casualty occurred.

Further information will be provided in chapter 5 with the detailed analysis of the contributing factors and safety issues, thus explaining the context in which the "human action" took place, even at organisation and system level. Therefore, this further step of analysis will try to explain why – for example – the OOW was affected by fatigue and the vessel went aground following the course of action of the crew, why the ship's Master decided to tackle a manoeuvre not aligned to COLREG.

The codification of "human action" in EMCIP includes some elements from CREAM's "human error"; it may be related to its manifestations, *i.e.* "error modes" (*e.g.* when an action is carried out too late) and its conditions, *i.e.* "observation", "interpretation" and "planning".

Specific personal factors, either permanent or temporary, associated to performance variability are also captured by the EMCIP taxonomy.

4.1.1.1 Human action manifestation – Error modes

Error modes refer to the ways the manifestation of errors occurred.

Error Modes	Nr.	%
Action at a wrong time - Timing - Omission	79	30.4%
Action at a wrong time - Timing - Late	78	30.0%
Action at a wrong type - Direction	24	9.2%
Action out of sequence - Sequence	19	7.3%
Action at a wrong time - Timing - Other	15	5.8%
Action at a wrong time - Timing - Early	11	4.2%
Action at a wrong type – Distance / magnitude	10	3.8%
Action at a wrong type - Speed	9	3.5%
Action at a wrong time - Duration	7	2.7%
Action at a wrong object	5	1.9%
Action at a wrong type - Force	3	1.2%
Total	**260**	**100.0%**

Table 14 - Action modes

The most prominent manifestations of error are related to the wrong timing of a given action, either omissions or actions executed too late.

Examples relevant to the analysis of navigation accidents include the lack of change of course, or its delayed execution, in a crossing situation involving two ships evolving is a collision.

[19] B. Accou, F. Carpinelli (2021) *Systematically investigating human and organisational factors in complex socio-technical systems by using the Safety Fractal Analysis method*, Applied Ergonomics, Vol.100, April 2022
[20] Permanent Cooperation Framework for AI - Salient points for meetings PCF10 and PCF11, available at https://portal.emsa.europa.eu/web/emcip/documents

4.1.1.2 Human action - General conditions

The basic conditions of “human actions” are also divided in categories according to the status of the person. A first distinction concerns “analysis” and “synthesis”.

- “Analysis”, refers to the functions that are invoked when a person tries to determine what the situation is, typically including observation, identification, recognition, diagnosis, *etc*. Analysis is encoded in EMCIP by the attributes “observation” and “interpretation”, thus describing aspects of receiving data and information from the devices, whether it is as a reaction or response to a signal or an event or it is actively looking for information.
  Missed observation, either overlooked cue, signal or measurement, appears the most frequently reported cause for observation issues.

Observation	Nr.	%
Observation missed - Overlook cue / signal / measurement	129	57.3%
Local observation - Incorrect recognition/stimulus	46	20.4%
Local observation - Other	21	9.3%
Local identification - Partial identification	14	6.2%
Local identification - Mistaken cue	12	5.3%
Observation missed - Other	3	1.3%
Total	**225**	**100.0%**

Table 15 – Human action general conditions (Observation)

  Examples include the missed or late observation of floating objects or signals coming from nearby vessels. Most of the interpretation issues concern delays in interpretation, i.e., not made in time, faulty diagnosis and wrong decisions are the most reported causes of cognitive functions.

Interpretation	Nr.	%
Delayed interpretation	70	27.5%
Local diagnosis - Wrong diagnosis	45	17.6%
Decision error - Wrong decision	41	16.1%
Local diagnosis - Incomplete diagnosis	28	11.0%
Local prediction - Unexpected state change	16	6.3%
Local prediction - Process speed misjudged	12	4.7%
Wrong reasoning - Wrong priorities	11	4.3%
Wrong reasoning - Deduction error	9	3.5%
Decision error - Decision paralysis	8	3.1%
Wrong reasoning - Induction error	5	2.0%
Decision error - Partial decision	4	1.6%
Local diagnosis - Other	2	0.8%
Local prediction - Unexpected side	2	0.8%
Decision error - Other	1	0.4%
Local prediction - Other	1	0.4%
Total	**255**	**100.00%**

Table 16 - Human action general conditions (Interpretation)

  Examples include the status of the OOW’s monitoring of the vessel’s progress, taking into consideration the interpretation of the displayed information from the navigation instruments, the alarms triggered by the ECDIS, or the kinematic manoeuvre of the ship.

- Synthesis” refers to the functions applied when a person decides what to do and how to do it; this typically includes choice, planning, scheduling, etc. Regarding planning, the most frequent error triggers are wrong plans, in the sense that they do not achieve their purpose, and incomplete plans, i.e., they do not contain all the details needed when they are carried out.

Planning	Nr	%
Local plan - Wrong plan	97	42.4%
Local plan - Incomplete plan	78	34.1%
Priority error - Wrong goal selected	48	21.0%
Priority error	3	1.3%
Local plan	3	1.3%
Total	**229**	**100.00%**

Table 17 - Human action general conditions (Planning)

Examples of planning issues are associated with the preparation of avoidance manoeuvres and outlining of passage plans.

4.1.1.3 Human action - Specific conditions

EMCIP distinguishes the personal factors affecting the performance variability – *i.e.* the continual adjustments necessary to cope with variability in demands and conditions - in two in two categories, depending on their persistence on the affected person:

- Temporary (*e.g.* stress, fatigue *etc*) are transitional conditions impacting the individual performances for a limited timeframe;
- Permanent (*e.g.* cognitive style, bad eyesight *etc*) are persistent conditions affecting the individual

Two hundred forty-four items have been reported as "temporary conditions". The most frequently reported are "Performance focus – lack of precision" and "Inattention" indicating, respectively, reduced precision of actions (e.g. in reaching the target value) and signals or events missed due to inattention.

Temporary Conditions	Nr.	%
Performance focus - Lack of precision	69	28.3%
Inattention	53	21.7%
Distraction - Task not completed	28	11.5%
Fatigue - Fell asleep	18	7.4%
Distraction - Loss of orientation	11	4.5%
Fatigue - Delayed response	10	4.1%
Physical or psychological stress - Frustration/Preoccupation	8	3.3%
Memory failure	7	2.9%
Distraction - Goal forgotten	6	2.5%
Performance focus - Increasing misses	6	2.5%
Physical or psychological stress - Alcohol	6	2.5%
Physical or psychological stress - Emotional overload	5	2.0%
Fear	4	1.6%
Physical or psychological stress - Routine; monotony	4	1.6%
Physical or psychological stress - Extreme concentration	4	1.6%
Fatigue - No response	2	0.8%
Physical or psychological stress - Other	1	0.4%
Distraction - Other	1	0.4%
Fatigue - Other	1	0.4%
Total	**244**	**100.0%**

Table 18 - Human action temporary conditions

Regarding the permanent conditions, "Cognitive bias – illusion of control" is the most reported. It refers to the situation where the person would believe that the chosen actions control the developments in the system.

Permanent Conditions	Nr.	%
Cognitive bias - Illusion of control	44	46.3%
Cognitive bias - Incorrect revision of probabilities	14	14.7%

Cognitive bias - Confirmation bias	9	9.5%
Cognitive bias - Hindsight bias	7	7.4%
Cognitive bias - Attribution error	7	7.4%
Cognitive bias - Focus gambling	5	5.3%
Cognitive style - Simultaneous scanning	4	4.2%
Cognitive style - Other	2	2.1%
Cognitive style - Conservative focusing	2	2.1%
Cognitive bias - Hypothesis fixation	1	1.1%
Total	**95**	**100.00%**

Table 19 - Human action permanent conditions

4.1.1.4 Human action – Casualty stage

The EMCIP taxonomy allows linking the accident events to the specific casualty stage, for instance the casualty stage or the following emergency phase (*e.g.* ship evacuation, use of life saving tools *etc*).

Around 92% of the accident events type "human action" concerned the casualty itself, while around 8% was related to the emergency phase:

Casualty Stage	**Nr.**	**%**
Casualty or accident	435	91.8%
Emergency - Damage/danger control	22	4.6%
Emergency - Other	12	2.5%
Emergency - Abandon ship - Other related operations	3	0.6%
Emergency - Abandon ship - Live saving use	2	0.4%
Total	**474**	**100.00%**

Table 20 - Casualty stage - Human action

5. Contributing Factors

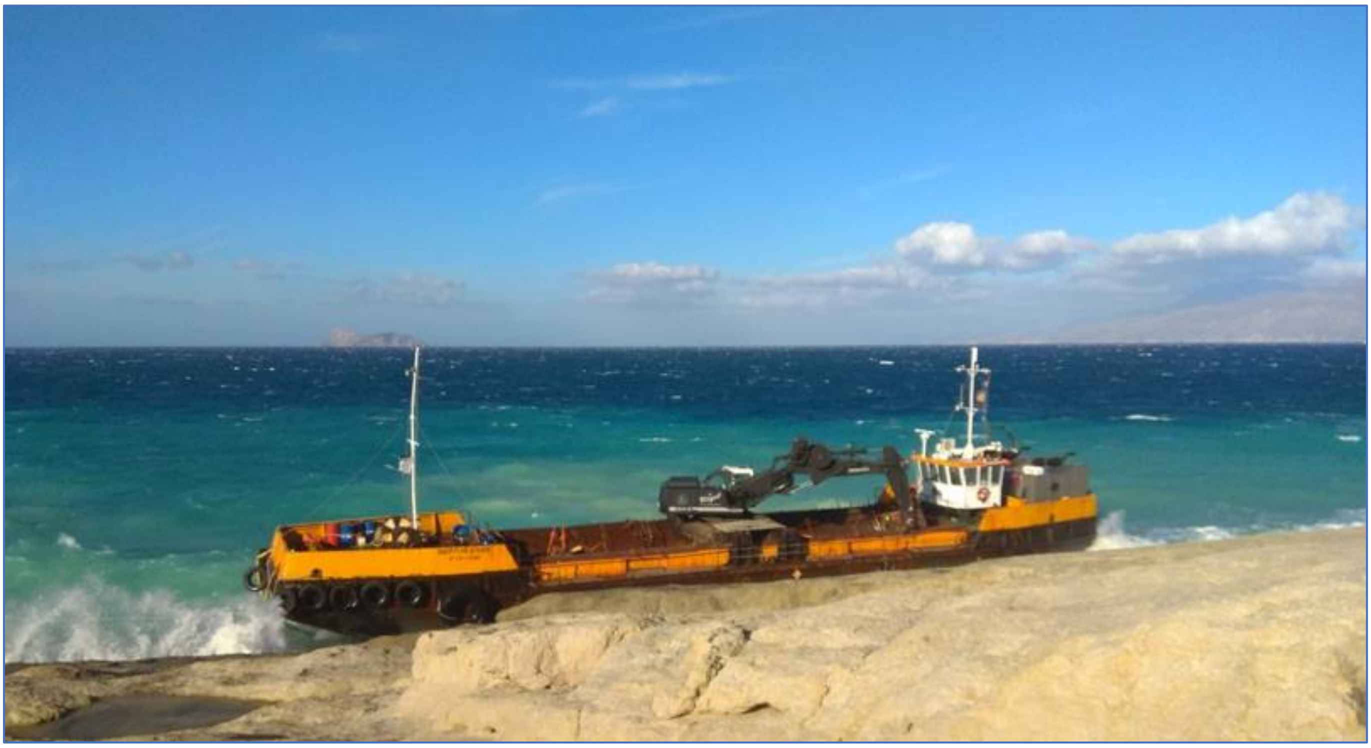

Figure 12 – Grounding of tug boat “Viking” and towed dredger “Neptun Khan”, south of Crete Island on 7/12/2018 – HBMCI (Greece)

This chapter looks into the contributing factors (CF) reported in the system to detect possible safety issues following the execution of a safety investigation.

Similarly to the analysis of “human action”, all the reported CF have been taken into account, either directly associated with collisions, groundings and contacts or indirectly linked to other casualty events that led to navigation accidents.

5.1 Potential safety issues (SI)

One of the issues with accident databases is not so much putting the data in, but getting it out as useful information. Yet a database can clearly be useful for safety learning, as it comprises an evidence base from which the most common and severe accidents, as well as their causes and contributory factors, can emerge. Rather than learning from each individual accident, more general and even system-wide lessons can be drawn by looking across different events, and the resultant lessons can have a more powerful impact on safety[21].

Additionally, the need for change may not be warranted by a single event until it is realised that there are many more similar events. Databases can therefore be a call to action and a means of prioritising safety actions. Each accident may look different and be surrounded by specific circumstances, each ship and crew may be unique, but there might be problems that clearly appear on a horizontal basis (*e.g.* Bridge Resource Management, as it is demonstrated afterwards).

Given the wide scope of the analysis, comprising almost 35% of the occurrences in EMCIP falling within the scope of the AID, it is not surprising that a large amount of contributing factors had to be processed. The EMSA methodology applied to similar analysis of EMCIP data[22] constituted the baseline and it was integrated with additional input to develop a pragmatic taxonomy supporting the data processing, in particular to group the contributing factors into homogeneous categories with appropriate granularity. In this respect, the SHIELD

[21] “Towards safety learning culture” – SAFEMODE white paper
[22] Ref. EMCIP analysis on accident involving Fishing vessels, RO-RO and Container vessels.

taxonomy[23] and its definitions elaborated in the context of the EU-funded SAFEMODE project have been taken into account.

The analysis considered 1,637 contributing factors reported in 351 safety investigation reports, both directly and indirectly linked to navigation accidents that have been grouped into nine "safety issues", as presented in the table below.

Their distribution shows that most of the reported issues concern "work operational methods", "organisational factors" and "risk assessment" (almost 66% of the contributing factors).

Safety Issues (SI)	CF Nr.	%
Work / Operation Methods	594	36.3%
Organisational Factors	310	18.9%
Risk Assessment	171	10.4%
Environment	139	8.5%
Individual Factors	119	7.3%
Tools & Hardware	117	7.1%
Competence & Skills	69	4.2%
Emergency response	61	3.7%
Operation planning	57	3.5%
Total	**1,637**	**100.0%**

Table 21 - Safety issues (Directly and indirectly linked to navigation accidents)

Out of the 1,637 contributing factors reported in total, 1,456 refer to the casualty events directly linked to navigation accidents according to the following distribution:

Casualty event	Safety Issues (SI)	Nr	%
Grounding	Work / Operation Methods	237	16.3%
	Organisational Factors	145	10.0%
	Risk Assessment	63	4.3%
	Individual Factors	57	3.9%
	Environment	43	3.0%
	Operation Planning	38	2.6%
	Competence & Skills	31	2.1%
	Tools & Hardware	22	1.5%
	Emergency response	17	1.2%
	Total Grounding	**653**	**44.8%**
Collision	Work / Operation Methods	253	17.4%
	Risk Assessment	84	5.8%
	Organisational Factors	80	5.5%
	Environment	59	4.1%
	Individual Factors	49	3.4%
	Tools & Hardware	34	2.3%
	Emergency response	25	1.7%
	Competence & Skills	22	1.5%
	Operation Planning	12	0.8%
	Total collisions	**618**	**42.4%**
Contact	Work / Operation Methods	58	4.0%
	Organisational Factors	38	2.6%
	Tools & Hardware	20	1.4%

[23] Ref. to SHIELD taxonomy, developed in the context of the EU-funded SAFEMODE project, to which EMSA contributed as a technical advisor. More information on the project is available at https://www.safemodeproject.eu/

	Environment	18	1.2%
	Risk Assessment	17	1.2%
	Emergency response	13	0.9%
	Individual Factors	9	0.6%
	Competence & Skills	6	0.4%
	Operation Planning	6	0.4%
	Total contact	**185**	**12.7%**
Navigation accidents	**Total**	**1,456**	**100.0%**

Table 22 - Safety issues (Directly linked to navigation accidents)

Each safety issue, both directly and indirectly linked to navigation accident, has been further investigated into Areas of Concern (AoC) to get a detailed understanding of the homogenous factors explaining its manifestation.

5.2 Work/operation methods

Working methods in the multiple operation areas onboard are structured and supported by the Safety Management System (SMS) implemented by the shipping company.

The analysis showed that this is the most reported safety issue, with 242 investigations addressing 594 contributing factors concerning work/operation methods.

The Areas of Concern reported for "Work/operation methods" are summarised in the following table:

AoC	Nr. CF
BRM (Bridge Resource Management) Coordination	94
Use electronic equipment (navigation devices)	94
Work methods and supervision	63
BRM Resource availability	63
Communications (External)	53
Coordination with 3rd parties	48
Maintenance implementation on board	41
Alarm setup	41
Communications (Internal)	31
Use of equipment	26
Multitasking	26
SMS implementation on board	14
Total	**594**

Table 23 - Work / operation methods AoC

The 12 Areas of Concern relevant to this safety issue are described below, in descending order according to their frequency:

- **BRM Coordination:** Bridge Resource Management concerns the effective management and utilisation of all resources, human and technical, available to the bridge team to ensure the safe completion of the vessel's voyage.
  Several issues have been reported in task coordination of the crew members, particularly of the resources allocated to the bridge and delegation of tasks.
  Investigations pointed out issues in ensuring that effective bridge resource management is achieved due to the excessive workload of the master, who had to carry out a significant number of actions simultaneously, thus overlooking effective workload sharing.

Examples include the failure to adequately organise the bridge team for a given activity, leading to unsafe performances, or the request to execute inappropriate tasks to the specific situation (*e.g.* ordering the OOW to occasionally plot the ship's position on the chart rather than focusing on the continuous monitoring of the vessels in a close-quarter situation).
In other situations, the tasks of the bridge team had been loosely defined, thus putting at risk the effective coordination of tasks on board.

- **Use of electronic equipment (navigation devices):** it is linked to the use of electronic equipment on the bridge, like ECDIS, ARPA, GPS and RADAR. The equipment at stake, particularly ECDIS, is fundamental to support the bridge team in monitoring the navigation and conducting a risk assessment.
  Data reported suggest that operators in various situations did not exploit the full potential of the navigation equipment's technical features, such as setting up safety contours or selecting the appropriate map scale. In other cases, overconfidence in the navigational tools and no double-check of the actual movement of the ship with the navigational picture displayed by the tools had an impact on the situational awareness of the bridge team.
  It was also found that the OOW did not interrogate objects displayed by the ECDIS and that the plotting did not follow recommended practices. The way the radar was used to avoid close-quarter situations was reported in a number of events.

- **Work methods and supervision:** this category refers to the Master's leadership, supervision or oversight and other working practices affecting navigation. Availability, competency, quality, timeliness of leadership, provision of feedback to the team does not meet task demands and impact on the situation.
  Examples include the supervision of the effectiveness of look-out in close-quarter situations, the OOW plotting approach of the ship position on nautical charts, or the selected speed by the OOW for manoeuvring.

- **BRM Resource availability:** This Area of Concern is part of the reported issues about Bridge Resource Management and concerns the lack of availability on the bridge of skilled resources, *e.g.* the Master or key crew members, during critical navigation phases, particularly during night time.
  Lookouts not posted in high-density traffic areas or when approaching other vessels, and the common practice of the OOW remaining alone on the bridge were frequently reported.
  In some cases, it was not possible to post lookouts on the bridge because all deck rating were engaged during the daytime in specific operations (*e.g.* cargo hold cleaning) and were resting during the nigh time to cope with fatigue. Therefore, they were not available for the lookout tasks during night-time.

- **Communications (External):** Issues concerning effective communications ship-to-ship or ship-to-shore (*e.g.* VTS) were reported in several cases, mostly leading to collisions and groundings.
  Misspoken, misread or misheard information due, for instance, to linguistic barriers or lack of mutual understanding between ships led to misjudgement of the ship's intentions, thus contributing to the unwanted outcome.
  Failure to use clear and concise terms and lack of clarity contributed to misunderstanding in the communications with pilots, tugs and VTS, particularly when message markers were not used.

- **Coordination with 3rd parties:** Issues in coordinating tasks between the bridge and 3rd parties, particularly pilots, were frequently reported.
  Apparently, this Area of Concern can be summarised as the ineffective incorporation of the bridge team pilot and had been declined in various facets. In some cases, critical information concerning *e.g.* ship's manoeuvrability has not been made available to the pilot. In other situations, the pilot did not share plans and goals with the crew members or did not sufficiently make it clear, thus there was no common understanding of the pilot's intention before initiating manoeuvres. Other examples include either the a-critical acceptance of the pilot's decision without constructive challenges by the Master, who became disengaged from the pilotage process, thus allowing the latter to become the sole decision-maker or in the decision to keep the pilot at the helm, rather than a seafarer.

- **Maintenance implementation on board:** Maintenance is a critical domain for sailing vessels, given the complexity of shipborne systems and equipment. This Area of Concern refers to the implementation of the maintenance policies and procedures established in the SMS.

- **Alarm setup:** Relates to the conscious decision of the bridge team to deactivate the safety alarms embedded in the navigation equipment. Examples include the disabling of the several alarm types made available by the ECDIS when the ship approaches shallow waters or deviates from the planned route. Other examples concern the voluntary deactivation of Bridge Navigational Watch & Alarm System (BNWAS)[24].

- **Communications (Internal):** Good communication between the crew members is the key to successful Bridge Resource Management. The effective transfer of information is a complex process. It requires information to be conveyed when needed, understood and acknowledged by the receiver and clarified if needed. In many cases, it has been seen that the information needed always existed but it was not made available to those who needed it at the right time.

- **Use of equipment:** This Area of Concern is about the use of critical tools supporting the nautical conduct of the ship, e.g. use of compasses to determine visual bearing as additional sources for risk assessment, accurate situational awareness and the use of fog signals in the situation of low visibility. Other examples include the misuse of secondary steering gear or the operation of the wrong controllable pitch propeller (CPP) commands.

- **Multitasking:** Multitasking, meaning the apparent human ability to perform more than one task at the same time, led to lookouts becoming involved in other jobs, thus distracting from their primary task.

- **SMS implementation on board:** This Area of Concern refers to the effective implementation of the existing plans and procedures relevant to navigation foreseen in the existing SMS that, given the circumstances, could have prevented the accident or mitigated its consequences.

5.3 Organisational Factors

Organisational and management posture plays a pivotal role for ship safety, regardless of the type of vessel. Three hundred and ten contributing factors concerning companies’ policies and supervision from shore-based authorities have been reported in 155 investigations.

AoC	Nr. CF
Resource Availability (Plans and Procedures)	73
Culture Climate	65
Resource Availability (Operational information)	44
Resource Availability (Tools)	42
Compliance with regulations and standards	23
Review Critical Tasks	20
Resource Availability (Manning)	17
Maintenance policy (SMS)	17
Resource Availability (Standing Orders)	9
Total	**310**

Table 24–Organisational factors (AoC)

The following Areas of Concern have been identified:

- **Resource Availability (Plans and Procedures):** Publications and written documentation are not sufficient to ensure that a task is carried out safely. Procedures may exist but can be poor and cannot be used to perform

[24] This is a monitoring and alarm system which notifies other navigation officers or master of the ship if the OOW does not respond within configurable thresholds or is incapable of performing the watch duties efficiently.

the task they are intended to support. Even where good procedures exist, they do not account for all the operational circumstances they are expected to be applied (work as imagined *versus* work as done).

- **Culture climate**: Low company morale may lead to a poor attitude towards safety and organisational safety. Those working in the organisation don't believe the organisation 'cares' for them, and likewise, they do not 'care' about the organisation. This is reflected, for instance, in the low prioritisation of safety in daily operations. Various safety investigations pointed out that the culture to keep a tight schedule, under the company policy to minimise costs, contributed to unsafe conditions that eventually led to accidents. Examples include Masters prone to accept additional risks to meet the increased demand, the tendency not reporting operational defects that would have required the vessel to spend additional time in port for repairs, the pressure to adhere to tight schedule leading to the decision to sail in marginal conditions of visibility and with poor forecast.

- **Resource Availability (Operational information):** This issue is about the lack of operational information necessary to safely perform tasks or meet the organisation's requirements of a safe operation.
Information at stake may include weather briefings/forecasts, operational planning material or other information necessary for safe operations. This might also include lessons learned and operational incident data within the company's availability that are not disseminated to the sharp end operators.

- **Resource Availability (tools):** Equipment and tools are not made available to the operators, yet they are needed to perform critical tasks. Examples have been found onboard of ships (*e.g.* lack of nautical charts) and ashore (*e.g.* missing navigational aids in waterways and port areas or lack of tugs of adequate power in port).

- **Compliance with regulations and standards:** this Area of Concern relates to compliance to the international, EU and national legal instruments. Breach in COLREGs and STCW provisions, respectively, in implementing the right of way when two vessels are crossing and in watchkeeping minimum setup contributed to collisions and grounding. Moreover, it was found that several navigation accidents in port areas were prompted by the lack of compliance with local regulations concerning the use of pilots and tugs.

- **Review Critical Tasks:** Indicates lack of control by management, either on board or ashore. Examples include the lack of control by technical inspectors of the conformity of pieces of equipment after shipyard repairs or the improper handover of ships from shipyard to the owner.

- **Resource Availability (Manning):** There is insufficient suitably qualified and experienced personnel onboard to safely perform the assigned tasks. This issue materialized several times in navigation accidents. Examples include the working culture encouraging the OOW to be alone on the bridge or the Master's decision to maintain the bridge without a look-out as a trade-off to meet the work demands with the resources allocated. In other cases, the manning was considered sufficient for regular ship operations, but became short during emergencies, where additional unforeseen tasks topped up the ordinary workload.
Other investigations revealed that the OOW and the Master were restricted in their actions to prevent the marine casualty due to lack of qualified seafarers on the bridge.

- **Maintenance policy (SMS):** Maintenance is a scheduled process depending on the operational and constructive characteristics of the ship's equipment. This is generally embedded in the ship's SMS.
Examples include existing maintenance policies that do not cover crucial equipment, like CPP, wheelhouse or mismatch of SMS procedures with the manufacturers' guidance.

- **Resource Availability (Standing / night orders):** These are written requirements by the Master, providing the OOW with guidelines to ensure safe ship navigation and operations whether at sea or at port. Standing orders normally encompasses a wide array of aspects of navigation and rules of conduct that should be followed at all times by the officers on duty. The night orders are a supplement to the standing orders and become applicable as the Master proceeds to take rest during the night[25].
The ambiguity of these peculiar guidelines, or their absence, contributed to accidents at sea, particularly collisions and grounding occurring during night time.

[25] https://www.marineinsight.com/guidelines/masters-standing-and-night-orders/

5.4 Risk assessment

Safety and risk assessment, and reviews of tasks and procedures based on such assessment, are essential components of the safety culture and contribute to an effective decision-making process. Conversely, critical actions not preceded by at least a basic safety assessment may result in unexpected and unwanted events.

As it appears from the EMCIP data, issues linked to “Risk assessment” have been reported in 133 safety investigations, comprising 171 contributing factors.

The distribution of the contributing factors per Area of Concern is summarized in the following table:

AoC	Nr. CF
Safety Awareness	125
Environment Impact	39
Risk assessment for specific operation	7
Total	**171**

Table 25 – Risk Assessment (AoC)

The Areas of Concern relevant to “Safety assessment – review” are detailed as follows:

- **Safety awareness:** Proper collection, correct processing and prioritisation of information from various sources are crucial for effective risk assessment, in particular, to prevent collisions and groundings. This Area of Concern is mainly linked to collision and includes risks associated with perception, interpretation and full appraisal of the evolving nautical picture. Factors that contributed to navigation accidents include the misinterpretation of the intentions of other ships and the insufficient assessment of the speed and manoeuvrability of the own vessel. Risk mitigation issues when navigating in waterways and channels were also reported. Occurrences included the wrong assessment of the position of a vessel within a deep-water channel that, in turn, led to a grounding.

- **Environmental impact**: Anticipating the impact of meteorological conditions, like wind, current and low visibility, is essential for risk assessment and should be duly taken into account for safe navigation. Many investigations found that the bridge team did not estimate the risks associated with *e.g.* rapidly changing weather conditions or the tide effect when navigating in restricted waterways, thus mainly leading to collision or grounding.

- **Risk assessment for specific operations:** Safety assessment when executing critical operations, for instance, the selection of the anchorage area, or when operating specific systems like the ship’s propulsion control system were also addressed in safety investigation reports.

5.5 Environment

The environmental factors, either internal or external the ship, may affecthuman performance and contribute to errors or variations from the normal working pathway. Such factors, reported in 139 contributing factors stemming from 102 investigations, mainly led to collisions and groundings. Differently from the issues concerning risk assessment, Areas of Concern under this safety issues refer to the actual manifestation of environmental factors negatively impacting on the safe navigation.

AoC	Nr. CF
External environment impact	69
Visibility	22
Restricted Ship Manoeuvrability	18
Social environment on board	15
Hindrance from other ships	11
Physical environment on board	4
Total	**139**

Table 26 – Environment (AoC)

The following Areas of Concern have been identified:

- **External environment impact:** This Area of Concern wraps up the several contributing factors capturing the actual effect of abrupt wind variations, gales, gusts, currents and tide that might have caused drift during the navigation.

- **Visibility:** Poor visibility, especially fog in restricted fairways or in areas with hight traffic density proved to be detrimental when the crew did not apply maximum caution or did not request the recommended tug assistance.

- **Restricted ship manoeuvrability:** The confined nature of narrow waterways or navigation constraints due e.g. to the deep draught might have reduced the ship’s manoeuvrability options mainly contributing to collisions.

- **Social environment on board:** Operator's personality traits (e.g. authoritarian, over-conservative, impulsive, invulnerable, submissive) negatively affect the way to interact with other team members, thus contributing to degraded performance. Examples of this Area of Concern include: (i) the hesitation of a junior OOW not to challenge the decision taken by senior Officers, (ii) tensions between the Master and pilots when negotiating manoeuvres, (iii) hierarchy gap between the master and the junior team members adversely affecting the bridge team interactions.

- **Hindrance from other ships:** Hydrodynamic effect from the incoming traffic or interactions with other passing vessels, particularly fishing vessels, increased the complexity of the environmental dynamic and influenced the decision-making process of the OOW, thus contributing to the accident.

- **Physical environment on board:** Environmental conditions on the bridge, like loud music or excessive vibrations, affected the operator’s ability to hear, thus reducing the individual performances of the OOW.

5.6 Individual factors

The physical andpsychological conditions may well influence the actors' behaviour or actions and contribute to navigation accidents.

Individual factors have been reported in 85 investigations, making a total of 119 contributing factors:

AoC	Nr. CF
Fatigue	32
Misperception / Misinterpretation / Distraction	28
Situational awareness	15
Physical / Mental Unfitness	13
Cognitive Workload	15
Unawareness of actual dangers	10
Overconfidence	6
Total	**119**

Table 27 – Individual factors (AoC)

The following Areas of Concern have been identified:

- **Fatigue:** Fatigue applies to both cognitive and physical domains. The former refers to the diminished mental capacity due to restricted or shortened sleep, mental activity during prolonged wakefulness or disturbance of circadian rhythm. The latter concerns the diminished physical capacity due to overuse, thus leading to degraded task performance. Examples from investigations include much overtime work or several hours of continuous work without resting, lack of or disturbed sleep, inadequate alternance work/rest.

- **Misperception / Misinterpretation / Distraction:** This Area of Concern refers to the inadequate operator's performance derived from:
    - misread, misinterpretation or not recognized information presented by tools or instruments or other input from the environment
    - interruption and/or inappropriate redirection of operator's attention.

  Examples are the misunderstanding of the intention of a crossing ship based on the visual observation, the misinterpretation of the lights of a nearby vessel during the night, the misread of the depth of a shoal presented by the in the ECDIS.

- **Situational awareness:** Operator's lack of alertness or readiness to process immediately available information, the interruption and inappropriate redirection of operator's attention contributed to errors. Examples include the lack of micro-tasks or stimulation in a very quiet environment that reduced alertness. Some safety investigations highlighted that the routine and monotony of functions in daily operations have reduced the focus of crewmembers and therefore contributed to some accidents.

- **Physical / Mental Unfitness:** The operator's physical and mental strength and coordination were inadequate to support tasks' demands. Most of the cases reported in EMCIP have been linked to alcohol consumption that impaired the operator's performance.

- **Cognitive Workload**: This is associated with the wearing effects of high operational speed of the unfolding situation that adversely impacted the cognitive processing, thus leading to unsafe operator performance. Examples include the impact of panic on the OOW when berthing following an unexpected development of the operation.

- **Unawareness of actual dangers:** The false sense of safety bringing the operator to ignores hazards or underestimate the risks associated to them, thus leading to unsafe performance. Examples refer to the attitude of the Master on final trip before retirement or the mindset of the OOW during frequently repeated voyages in reduced traffic density.

- **Overconfidence:** Inadequate estimation by the operator of personal capability, of the capability of others or the capability of equipment contributes to erroneous performance at work, for instance in the decision of the Master to approach the port without the pilot's guidance.

5.7 Tools and hardware (design/operation)

This safety issue relates to the design and operation of the vessel or its components used during the regular ship's activities[26].

A total of 90 investigations reported 117 contributing factors relevant to this safety issue, which has been mainly reported for "collisions" and "loss of control" (both with 34 relevant contributing factors), followed by "Grounding" (22 contributing factors).

The following table summarises the distribution of the contributing factors per Areas of Concern:

AoC	Nr. CF
Equipment Failure	50
Equipment Design / ergonomics	42
Bridge ergonomics	25
Total	**117**

Table 28 – Tools and hardware (AoC)

Four significant Areas of Concern relevant to this safety issue have been considered:

- **Equipment failure:** material fatigue is a common factor for the failure of mechanisms and appliances, especially when in the context of the sea environment and the vessels' operations. Examples of equipment breakdown include the excessive stress on mooring ropes, the high load on the hydraulic motor of the windlass or radar failures.

- **Equipment design/ergonomics:** include issues with the ship or equipment design that harmed the safe and effective operations.
  Reported issues concern improper design for audible alarms, the steering and azimuth thruster control joysticks, CPP commands, navigational lights and engine room ergonomics.

- **Bridge ergonomics:** This Area of Concern focuses on the issues related to the bridge ergonomics and design that harmed the safe and effective operations. Contributing factors concern the safety standards used for designing hardware (devices, mechanisms or deck layouts).
  Examples are the inadequate bridge illumination - too high or too low - that impaired, respectively, effective lookout during night watches or facilitated drowsiness.
  Other significant issues are the installation and design of alarms and indicators in positions not visible from the conning station.
  The ergonomics of specific devices on the bridge adversely affected the operators' performances, for instance the position of the Master's seat not suitable for proper observation, the blind zones on the windows or the location of VHF units obstructing the external visibility, the inappropriate positioning of the helm console or the inadequate OOW's chair design.

[26] The safety issues associated to the dedicated tools to tackle emergency situations are described in section 5.9.

5.8 Competence and skills

This safety issue comprises contributing factors that have been linked with issues related to operators' competences or skills.

Sixty-nine contributing factors have been found in 50 safety investigation reports, mainly linked to groundings (31 CF), followed by collisions (22 CF).

AoC	Nr. CF
Knowledge	30
Ability	23
Familiarisation	16
Total	**69**

Table 29 – Competence and skills (AoC)

The issues reported in EMCIP affect the following Areas of Concern:

- **Knowledge:** It refers to the operator not meeting general training or recurring training requirements for the task assigned to her/him, thus contributing to erroneous performance. Contributing factors reported in this area include a lack of knowledge in operating specific equipment, such as the CPP, ECDIS or radar, effective communications via VHF, understanding of COLREGs or ship stability.

- **Ability:** Regardless of the training provided, the operator capability to accomplish a task did not meet the performance levels expected from her/his skill level, thus contributing to erroneous performance. Examples are the appreciation of meteorological elements such as wind and currents or the practical capability to operate electronic equipment, like radar or ECDIS.

- **Familiarisation:** Insufficient experience with a task preventing the operator from properly executing it, thus contributing to erroneous performance. This Area of Concern encompasses familiarisation problems with the vessel's characteristics, assigned duties and the ship's operations. Examples include the lack of ship handling experience on the vessel for a new Master, the familiarisation of the OOW in using and configuring specific equipment (like the BNWAS or the ECDIS) and the steering response assessment. In some cases, it was noted that the master lacked familiarity with the procedure to save the data from the S-VDR, and thus not saving the relevant ship-related data for the subsequent safety investigation.

5.9 Emergency response

Issues concerning the processes, tools or actions made during an emergency have been reported in 49 investigations comprising 61 contributing factors.

Forty-one percent of the reported issues (25 contributing factors) are associated to collisions.

AoC	Nr. CF
Emergency handling	61
Total	**61**

Table 30 – Emergency response (AoC)

Emergency handling is the focus of this Area of Concern and refers to the crew's actions taken, or missed, to either identifying an emergency situation or dealing with its outcome. For instance:

- collision avoidance measures in restricted visibility, like reduced speed or the use of the prescribed fog signals, not implemented eventually contributed to the collision;
- coastal authorities not informed after the accident;
- slow reaction of the crew to sudden changes of weather conditions (*e.g.* gale or stong currents) when the vessel was at anchor or moored;

- crisis management, including the implementation of the the abandon ship process and the proper dissemination of information to the passengers following the marine casuaty;
- quality of contingency plans to deal with emergencies.

5.10 Operation planning

The conduct of ships envisages complex activities that are typically detailed in the SMS to provide both the company and the ship with appropriate plans and instructions to ensure compliance with the relevant mandatory requirements.

Fifty-seven contributing factors related to operational planning have been reported in EMCIP following the completion of 17 investigations.

“Grounding” is the casualty event with more contributing factors linked to operation planning (38).

AoC	Nr. CF
Passage Plan	46
Other operations planning	11
Total	**57**

Table 31 – Operation planning (AoC)

The following Areas of Concern have been identified:

- **Passage plan:** Missing or incomplete preparation for passage planning and monitoring was critical to several grounding occurrences. Several investigations pointed out that the passage plan was scanty or conducted not using all the available nautical information, such as “sailing directions”.

- **Other operation planning:** mainly refers to the planning detail of critical operations, such as mooring or berthing. Examples of contributing factors reported for this area are the inappropriate selection of berthing given the weather conditions and the inaccurate positions marked on the nautical chart, thus making its monitoring unreliable.

6. Safety recommendations and actions taken

Figure 13 – Collision between the River cruise ship “Viking Idun” and the chemical tanker “Chemical Marketer” on the Western Scheldt on 01/04/2019 – DSB (the Netherlands)

Safety recommendations (SR) are proposed remedial actions to prevent similar marine casualties and incidents in the future. These should be based on the analysis of evidence collected within the investigation process and the identification of causal factors. Safety recommendations can also be issued as a result of abstract data analysis.

Through the development of SR, AIB should clearly identify what needs to be done, who or what organisation or entity is to implement the change, and where possible, the urgency for completion.

Moreover, the stakeholders (*e.g.* shipping companies or national authorities), might have already implemented initiatives to prevent marine casualties before the conclusion of an investigation, so-called “action taken” (AT).

This chapter provides an overview of SR and AT reported in EMCIP with a view to describe how safety actions relevant to container vessels have been addressed.

6.1 Overview of safety recommendations

Nine hundred twenty-five (925) SR have been reported in EMCIP following investigations concerning navigation accidents[27].

As shown in the table below, more than 50% of the SR have been addressed to Companies and ship owners, followed by maritime administrations (approximately 2%) and local authorities, including Port Authorities, VTS Centres, SAR and counter pollution authorities.

[27] All the SR reported in EMCIP concerning safety investigations relevant to this analysis have been considered as this document covers horizontal issues.

Addresses	Nr.	%
Company/Owner associations	476	51.5%
Maritime Administration	204	22.1%
Port Authorities / SAR / VTS	104	11.2%
Other	65	7.0%
Crew / Crew associations	52	5.6%
Shipyard/Manufacturers	11	1.2%
Classification Societies	11	1.2%
Cargo Terminal	2	0.2%
Total	**925**	**100.0%**

Table 32 - SR addresses

The following tables discriminate the SR reported in EMCIP per addresses and topic, thus providing with higher details the type of remedial measures proposed by the AIB to the best placed recipients.

Addressee	Focus of the SR	Nr.
Company/Owner associations	Procedures - Operation	136
	Human Factors - Training Familiarisation	61
	Procedures - Compliance (regulations/legislation)	50
	Human Factors - Company & Management	48
	Ship structure and equipment - Ship equipment/system	30
	Procedures - Information dissemination	21
	Procedures - Inspection, maintenance & audit	19
	Procedures - Other	17
	Procedures - Emergency	16
	Procedures - Study/review	14
	Ship structure and equipment - Other	10
	Ship structure and equipment - Bridge navigation equipment	9
	Human Factors - Study/review	7
	Human Factors - Other	7
	Procedures - Company/Owner support	4
	Human Factors - Crew factors	4
	Human Factors - Medical; physical	4
	Procedures - Training	3
	Human Factors - Equipment	3
	Procedures - Port and terminal facilities	2
	Procedures - Pilot	2
	Ship structure and equipment - Propulsion systems	1
	Procedures - Documentation	1
	Human Factors - Working environment	1
	Ship structure and equipment - Steering gear	1
	Ship structure and equipment - Study/review	1
	Shore and water equipment - Other equipment	1
	Procedures - Meteorological services	1
	Shore and water equipment - Study/review	1
	Procedures - Manning	1
	Total	**476**

Table 33 - SR addressed to Companies / Owner associations

Addressee	Focus of the SR	Nr.
Maritime Administrations	Procedures - Compliance (regulations/legislation)	44
	Procedures - Other	19
	Procedures - Operation	15
	Shore and water equipment - Navigation aids	15
	Procedures - Study/review	14
	Shore and water equipment - VTS	13
	Ship structure and equipment - Ship equipment/system	11
	Other	8
	Procedures - VTS	8
	Procedures - Inspection, maintenance & audit	7
	Ship structure and equipment - Other	7
	Shore and water equipment - Study/review	5
	Shore and water equipment - Other equipment	5
	Human Factors - Training Familiarisation	4
	Procedures - Port and terminal facilities	4
	Procedures - Search and rescue	3
	Human Factors - Other	3
	Procedures - Information dissemination	3
	Human Factors - Study/review	2
	Ship structure and equipment - Study/review	2
	Human Factors - Company & Management	2
	Ship structure and equipment - Steering gear	2
	Ship structure and equipment - Ship structure	2
	Procedures - Meteorological services	1
	Procedures - Emergency	1
	Human Factors - Working environment	1
	Ship structure and equipment - VDR	1
	Human Factors - Crew factors	1
	Human Factors - Equipment	1
	Total	**204**

Table 34 – SR addressed to Maritime administrations

Addressee	Focus of the SR	Nr.
Port authorities / SAR / VTS	Procedures - Port and terminal facilities	28
	Procedures - VTS	17
	Shore and water equipment - Study/review	9
	Human Factors - Training Familiarisation	8
	Procedures - Operation	7
	Procedures - Other	7
	Shore and water equipment - VTS	7
	Procedures - Study/review	5
	Procedures - Compliance (regulations/legislation)	4
	Shore and water equipment - Navigation aids	4
	Procedures - Meteorological services	2
	Procedures - Information dissemination	2
	Ship structure and equipment - Ship equipment/system	1
	Human Factors - Medical; physical	1
	Human Factors - Company & Management	1
	Shore and water equipment - Other equipment	1
	Total	**104**

Table 35 – SR addressed to Port authorities, SAR authorities and VTS centres

Addressee	Focus of the SR	Nr.
Crew / Crew association	Procedures - Operation	17
	Procedures - Compliance (regulations/legislation)	17
	Human Factors - Training Familiarisation	6
	Human Factors - Company & Management	3
	Human Factors - Other	2
	Procedures - Information dissemination	2
	Procedures - Other	1
	Human Factors - Crew factors	1
	Ship structure and equipment - Ship equipment/system	1
	Procedures - Inspection, maintenance & audit	1
	Procedures - Emergency	1
	Total	**52**

Table 36 - SR addressed to crew and crew associations

Addressee	Focus of the SR	Nr.
Shipyard / Equipment Manufacturers	Ship structure and equipment - Ship equipment/system	4
	Shore and water equipment - Other equipment	3
	Shore and water equipment - Study/review	1
	Procedures - Other	1
	Procedures - Information dissemination	1
	Procedures - Port and terminal facilities	1
	Total	**11**

Table 37 - SR addressed to shipyards and equipment manufacturers

Addressee	Focus of the SR	Nr.
Classification societies	Procedures - Compliance (regulations/legislation)	3
	Procedures - Inspection, maintenance & audit	3
	Procedures - Other	2
	Human Factors - Training Familiarisation	1
	Ship structure and equipment - Ship equipment/system	1
	Ship structure and equipment - Propulsion systems	1
	Total	**11**

Table 38 - SR addressed to classification societies

Addressee	Focus of the SR	Nr.
Cargo terminals	Procedures - Operation	1
	Human Factors - Training Familiarisation	1
	Total	**2**

Table 39 - SR addressed to cargo terminals

Addressee	Focus of the SR	Nr.

Others	Procedures - Other	12
	Procedures - Compliance (regulations/legislation)	9
	Procedures - Study/review	7
	Ship structure and equipment - Ship equipment/system	4
	Procedures - Information dissemination	4
	Procedures - Operation	4
	Procedures - Meteorological services	2
	Human Factors - Training Familiarisation	2
	Procedures - Emergency	2
	Human Factors - Other	2
	Ship structure and equipment - Other	2
	Shore and water equipment - Study/review	2
	Human Factors - Medical; physical	2
	Procedures - Port and terminal facilities	2
	Procedures - Documentation	1
	Ship structure and equipment - VDR	1
	Ship structure and equipment - Study/review	1
	Procedures - Manning	1
	Shore and water equipment - Other equipment	1
	Procedures - Training	1
	Ship structure and equipment - Bridge navigation equipment	1
	Ship structure and equipment - Ship structure	1
	Procedures - Shore support	1
	Total	**65**

Table 40 - SR addressed to other parties

Around 62% of the issued SR (575) concern procedures, mostly with the focus on "operation", which appears consistent with the fact that the most detected safety issue is "Work / operation methods" (ref. section 5.2). Thus, these SR, apparently, have been addressed to reinforce the SMS on board the ships and the operational procedures laid down by shore authorities.

6.2 Overview of actions taken

Actions taken are appropriate safety initiatives autonomously implemented by stakeholders in the aftermath of the marine casualty or incident and should not be confused with the follow-up of the safety recommendations.

385 actions were taken by various actors took, mainly ship's owners and companies (65%), followed by port/shore authorities (12%).

Actor	Nr	%
Company/Owner associations	251	65.2%
Port Authorities / SAR / VTS	47	12.2%
Maritime Administration	44	11.4%
Other	23	6.0%
Crew / Crew associations	14	3.6%
Shipyard/Manufacturers	6	1.6%
Total	**385**	**100.0%**

Table 41 - Actors taking safety actions

An overview of the AT is provided in the following tables, which show the distribution per actor and the AT focus.

Actor	Focus of the AT	Nr.
Company/Owner associations	Procedures - Operation	68
	Human Factors - Training; skills; experience	44
	Ship structure and equipment - Other	23
	Procedures - Compliance (regulations/legislation)	18
	Human Factors - Company & Management	15
	Procedures - Other	11
	Procedures - Information dissemination	10
	Ship structure and equipment - Bridge navigation equipment	9
	Procedures - Study/review	8
	Human Factors - Other	7
	Human Factors - Equipment	5
	Ship structure and equipment - Study/review	5
	Human Factors - Study/review	4
	Procedures - Inspection, maintenance & audit	4
	Procedures - Port and terminal facilities	3
	Human Factors - Crew factors	3
	Other	3
	Ship structure and equipment - Steering gear	2
	Ship structure and equipment - Other shore support	2
	Human Factors - Medical; physical	2
	Procedures - Emergency	2
	Ship structure and equipment - Company/Owner support	2
	Procedures - Meteorological services	1
	Total	**251**

Table 42 - AT by companies/owner associations

Actor	Focus of the AT	Nr.
Port Authorities / SAR / VTS	Procedures - Port and terminal facilities	12
	Procedures - Compliance (regulations/legislation)	5
	Procedures - Operation	4
	Human Factors - Training; skills; experience	4
	Other	4
	Shore and water equipment - Navigation aids	3
	Shore and water equipment - Study/review	3
	Procedures - VTS	2
	Procedures - Study/review	2
	Shore and water equipment - VTS	2
	Procedures - Emergency	1
	Human Factors - Crew factors	1
	Procedures - Other	1
	Procedures - Information dissemination	1
	Human Factors - Company & Management	1
	Procedures - Meteorological services	1
	Total	**47**

Table 43 - AT by Port authorities, SAR authorities and VTS centres

Actor	Focus of the AT	Nr.
Maritime Administrations	Procedures - Compliance (regulations/legislation)	8

	Shore and water equipment - VTS	7
	Procedures - Other	6
	Shore and water equipment - Navigation aids	5
	Human Factors - Company & Management	3
	Procedures - Study/review	3
	Shore and water equipment - Study/review	2
	Procedures - Information dissemination	2
	Human Factors - Training; skills; experience	2
	Procedures - VTS	2
	Procedures - Operation	2
	Shore and water equipment - Other equipment	1
	Procedures - Emergency	1
	Total	**44**

Table 44 - AT by Maritime administrations

Actor	**Focus of the AT**	**Nr.**
Crew / Crew associations	Procedures - Operation	4
	Ship structure and equipment - Other	3
	Procedures - Compliance (regulations/legislation)	3
	Human Factors - Training; skills; experience	2
	Human Factors - Company & Management	1
	Procedures - Other	1
	Total	**14**

Table 45 - AT by crew and crew associations

Actor	**Focus of the AT**	**Nr.**
Shipyard / Manufacturers	Ship structure and equipment - Other	2
	Procedures - Other	2
	Procedures - Information dissemination	1
	Procedures - Inspection, maintenance & audit	1
	Total	**6**

Table 46 - AT by shipyards and equipment manufacturers

Actor	**Focus of the AT**	**Nr.**
Others	Procedures - Operation	5
	Ship structure and equipment - Other	4
	Shore and water equipment - Study/review	4
	Shore and water equipment - Navigation aids	2
	Human Factors - Training; skills; experience	2
	Procedures - Other	2
	Procedures - Study/review	1
	Shore and water equipment - Other equipment	1
	Procedures - Compliance (regulations/legislation)	1
	Procedures - Information dissemination	1
	Total	**23**

Table 47 - AT by other actors

Similarly to the safety recommendation overview, the largest component of safety actions taken is about “procedures” (around 52%).

7. Main takeout

Figure 14 – Collision between M/V “CSL Virginia” and Ro-Ro “Ulysse” off Cap Corse on 07/10/2018 – BEA Mer (France)

This analysis has focused on safety investigations data reported in EMCIP, in search of identification of categories of safety issues and more specific areas of concern that has been considered as factors contributing to the occurrences.

The main takeout of the analysis is summarised in this chapter. It points out some safety issues and safety recommendations considered by the AIB, as well as safety actions implemented by the relevant parties, that might have a potential horizontal impact on ship safety.

These findings derive from a qualitative assessment, guided by the reporting frequency in EMCIP, and include:

- Triggers of “human element” in navigation accidents;
- Coordination of bridge team, workload and resources availability;
- Conflicts of shipborne technology
- Bridge ergonomics and equipment design; and,
- Complexity of “procedures” in safety.

The outcome of the data analysis from the reported occurrences in EMCIP could be the starting point of a more formal and detailed process to gain further understanding on each of the areas of concern in the appropriate instances.

7.1 Triggers of “human element” in navigation accidents

Table 11 in chapter 4 highlights that 78% of collisions, groundings and contacts are associated with human action. Should this be understood as blaming the bridge team for this enormous contribution to navigation accidents?

The simple answer is no, as the data encoded in EMCIP show that human actions or decisions are not the cause of the adverse outcome, but mere events at the end of the accident event chain.

Moreover, detecting what is often referred to as “human error” is normally the starting point of safety investigators to understand why the “error” occurred.

The analysis in Chapter 5 indeed demonstrates that “behind the scenes” of “human errors” there are many contributing factors from various domains deriving from complex interactions between people and systems. On the one hand there are challenges with the coordination of the bridge team, ergonomic issues, lack of resources, completeness and realistic implementation of the SMS, use of technology, etc. On the other hand, the pressure to “get the job done”, thus to cope with the actual situation on board, pushes the crew to optimise the processes.

Therefore, blaming the key actors on the bridge, usually the Master or the OOW, for poor professional performance is just an oversimplification of the real world.

The following chart summarises the many factors that, at various levels, contributed to the operators’ performance variability, thus to the manifestation of “human error”. The internal sectors indicate the nine safety issues, while the external ones show the 46 Areas of Concern detected by the safety investigations (ref. chapter 5). The size of each sector reflects the number of reported contributing factor for each Area of Concern.

The chart stresses the complexity of the human element and that “human error” itself cannot be considered an acceptable “root-cause” explaining the marine casualty. Conversely, “human error” is a consequence of the socio-technical complex interactions, involving humans on board, organisations ashore, procedures and machines.

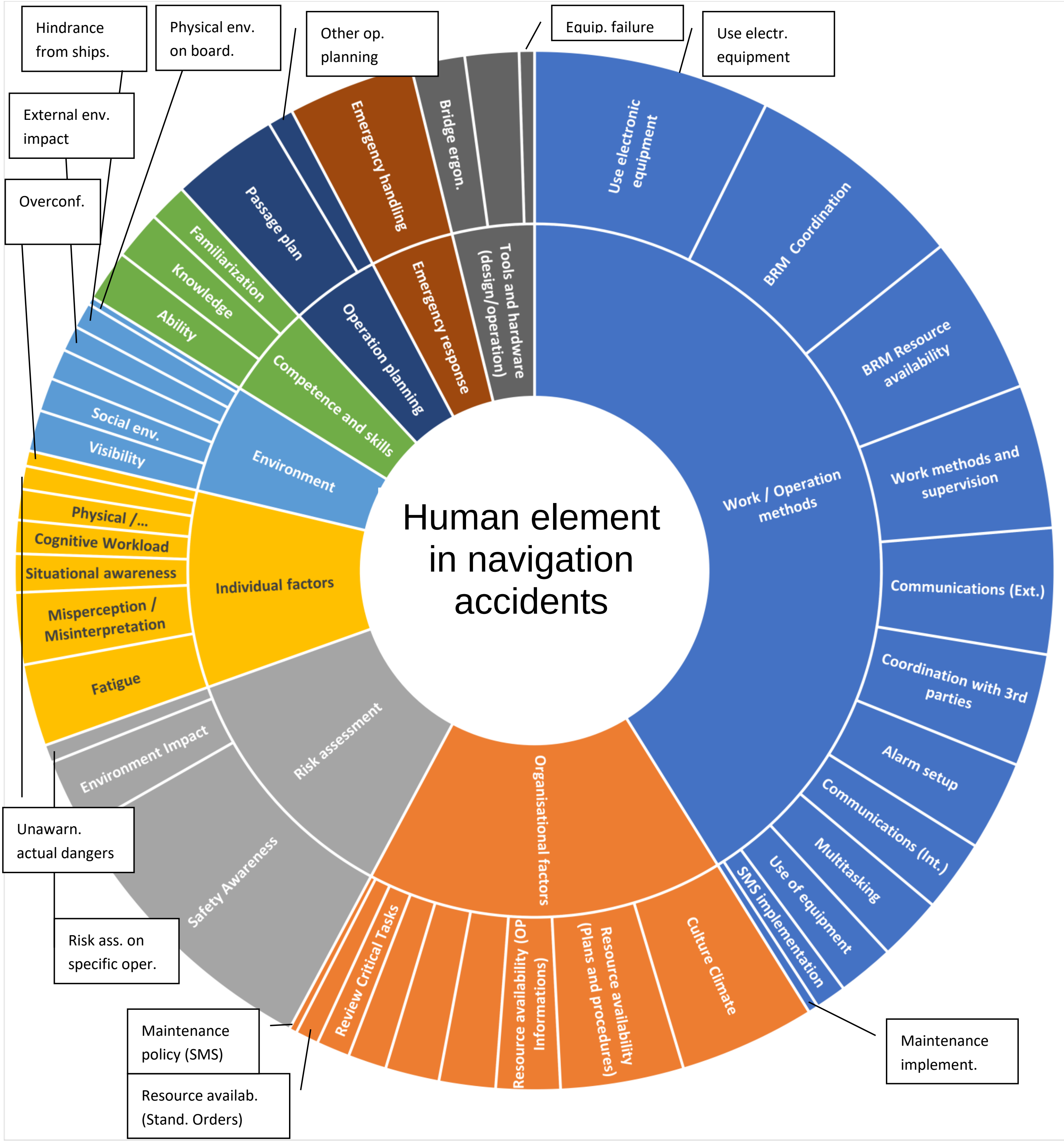

Figure 15 - Triggers of “Human action” in navigation accidents

7.2 Coordination of the bridge team, workload and resource availability

The issues concerning the coordination, resource availability of the bridge team, workload and fatigue were frequently reported and appeared in 143 safety investigations, corresponding to almost 41% of the safety investigations considered in this analysis.

AoC	% CF
Bridge Resource Management Coordination	37.9%
Bridge Resource Management Resource Availability	26.3%
Fatigue	13.3%
Multitasking	10.8%
Resource Availability (Manning)	6.3%
Cognitive Workload	5.4%
Total	**100.0%**

Table 48 - AoC relevant to bridge team

Data showed that the practice of keeping the OOW alone on the bridge was quite common, particularly during the night-time. Evidence from EMCIP showed that around 42% of the overall collisions in open seas[28] occurred between 00:00 hrs and 06:00 hrs.

Apparently, the decision to navigate without lookout was consciously accepted as a trade-off to meet the work demands on the ship with the resources allocated.

Another facet of this domain is multitasking, which is the ability to conduct two or more tasks simultaneously, both requiring attention and various advanced cognitive processes. Any human action requires a series of associated brain functions to execute the task efficiently. Moving from one task to another also requires complementary stages of goal shifting and rule activation. When conducting more than one task simultaneously, the interrelated cognitive processes establish priorities among tasks as the latter compete for attention and the mind's resources are allocated to them[29].

Some safety investigations also pointed out the inherent problems following the practise to employ seafarers in other tasks other than lookout or the engagement of the OOW in extra tasks, thus moving the focus from the main task, i.e. navigation monitoring, to other activities, frequently related to paperwork.

> *Flash* ran aground after she gradually set to starboard of her planned course and eventually running into shallow waters… Latent conditions and other safety factors include... the bridge watchkeeping practices (that) did not endorse the concept of bridge team management.

Safety investigation into the grounding of the bulk carrier "Flash" on the Galitons de l'est, Ile de la Galite, Tunisia on 25 June 2012 – MSIU (Malta)

[28] Either resulting in a safety investigation or not.
[29] Encyclopedia of clinical neurophsychology, 2011 https://link.springer.com/referenceworkentry/10.1007%2F978-0-387-79948-3_1466

7.3 Conflicts of shipborne technology

It is widely recognised that the enhanced technology on board ships enhanced safety of navigation and commercial efficiency. Navigational tools like ARPA, GPS, RADAR and, especially, ECDIS have undisputed benefits contributing to workload reduction and increase in situational awareness resulting from real-time positioning[30].

However, technology also introduced new complexities. Under particular circumstances, technology may become a burden for the bridge team, and the need to cope with the actual tasks may lead to the deactivation of installed specific safety barriers specifically designed to prevent navigation accidents, and that's where the conflict lies: technology is both the producer and the solution to potential safety issues.

Issues linked to the use of electronic navigation tools has been found in 83 safety investigation reports, corresponding to 23.6% of the total.

AoC	Nr. CF
Use electronic equipment (Navigation tools)	93
Alarm setup	41
Total	**134**

Table 49 – AoC relevant to conflict of shipborne technology

Examples encoded in EMCIP included alarms that were frequently triggered when navigating close to port areas, thus leading the crew member to deactivate or ignore them, particularly during critical operations.

It was also found that, although the ECDIS was the primary means of navigation monitoring and planning, its innumerable functions were not used to their full potential (*e.g.* safety contours), although the officers received the standard training on the tool.

Parallel indexing is a technique used as a measure to monitor the progress of a vessel on the track, to minimise the cross-track distance and to keep vessel at a safe distance from charted dangers, like the shoreline or rock. Various investigations pointed out that parallel indexing, or other manual monitoring plotting, was not regularly carried out to monitor the ship's movement.

Other reported issues concerned RADAR. One investigation found that, although all duty officers were aware of the RADAR's utility and familiar with the "guard zones" function, they were not using it to be alerted when targets entered a designated area or when their vessel was approaching a dangerous area.

Emblematic is also the approach to deactivate the alarms of the BNWAS which, being reported in 16 safety investigations (4.6% of the total), may suggest that this practice is wider adopted on board.

> By that time and shortly before the collision navigational watch was quiet … It emerged through the interview process that BNWAS was switched off during watches. As stated, it was a practice on board to have BNWAS deactivated and if needed OOW or Master could switch it on. Chief Officer had the BNWAS to off mode during his watch as according to his statement he was not feeling tired.

Safety investigation into the collision between M/V "Consouth" and M/V "Pirireis", 78 NM WSW of Peloponnese, Greece, on 29th April 2013 – HBMCI (Greece)

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[30] UK Marine Accident Investigation Branch, Danish Marine Accident Investigation Board (2021) *Application and usability of ECDIS*

7.4 Bridge ergonomics and equipment design

Ergonomics is the scientific discipline concerned with understanding interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design to optimise human well-being and overall system performance[31].

A typical operator on board must interact with many different systems, often with different interface styles. Complex and multiple interfaces can cause cognitive overload if the operator is presented with excess information. The operator can also be physically affected if the equipment is poorly placed. Depending on the shipowner, the shipyard and the suppliers of equipment, the composition of the equipment in the operator station can vary considerably and is often ergonomically sub-optimal[32].

Traditional ship bridges are often cluttered with equipment, buttons and levers. The placement depends on who arrived first to install their equipment at the shipyard, with no holistic and systemic focus on where to place equipment.

The design of specific components that are critical parts of wider systems, such as levers, switches or indicators, and whose original goals are to simplify the operator's actions and prevent error should not be overlooked.

Fifty-six contributing factors related to the bridge ergonomics or the design of pieces of equipment have been reported in 46 safety investigations, which correspond to more than 13% of the overall safety investigations reported in EMCIP.

AoC	**Nr. CF**
Equipment Design	33
Ergonomics Bridge	23
Total	**56**

Table 50 - AoC relevant to ergonomics

Data showed that the inadequate positioning of the equipment (*e.g*. VHF stations, screens, indicators) with respect to the position of the Master's chair, and / or the bridge illumination, negatively affected the awareness and capability to quickly react to unforeseen situations.

Problems in the design of audible and visual alarms have been reported as well, and consequently, the tools failed to promptly warn the bridge team of anomalies and emergencies during the navigation.

The investigation identified that the outbound City of Rotterdam had been set to the northern side of the navigable channel and into the path of the inbound ferry, but this had not been corrected because the pilot on board had become disoriented after looking through an off-axis window on the semi-circular shaped bridge. The car carrier was of an unconventional design and his disorientation was due to 'relative motion illusion', which caused the pilot to think that the vessel was travelling in the direction in which he was looking. Consequently, the pilot's actions, which were designed to manoeuvre the car carrier towards the south side of the channel, were ineffective.

Safety investigation into the collision between the pure car carrier *City of Rotterdam* and the Ro-Ro freight ferry *Primula Seaways* on 3rd December 2015, River Humber, United Kingdom – MAIB (UK)

[31] *International Ergonomics Association Executive Council, August 2000*

[32] *Improving safety on board ships through better bridge design, CIEHF*

7.5 Complexity of “procedures” in safety

The safety management system (SMS) is an organized system planned and intended to be implemented by shipping companies to achieve and maintain high safety and environmental protection standards.

SMS is an essential aspect of the International Safety Management (ISM) Code, and it details the tools that shall be followed to ensure safe ship operations. All commercial vessels under the ISM provisions are required to establish a safe ship management schema.

The ISM-Code is a mandatory international instrument to establish measures for ships' safe management and operation. The ISM-Code is part of the International Convention for the Safety of Life at Sea (SOLAS Convention Chapter IX) and the European Regulation (EC) No 336/2006.

Recognizing that no two shipping companies or shipowners are the same, and that ships operate under a wide range of different conditions, the ISM Code is based on general principles and objectives, which include assessment of all identified risks to one Company’s ships, personnel and the environment and establishment of appropriate safeguards[33].

Each Company has to document its SMS in a "Safety Management Manual" (SMM). At a higher level, the SMM incorporates policies that ensure the fulfilment of the objectives of the ISM Code. Consequently, procedures, practices and checklists are established to ensure that the relevant policy objectives are met.

The analysis of EMCIP data showed that deviations from procedures, or procedures that were not adequately detailed or even missing had been widely reported in EMCIP as factors contributing to accidents, particularly in Areas of Concern such as Bridge Resource Management coordination, work methods and supervision, use of navigation equipment, passage planning and implementation of maintenance.

As pointed out in chapter 6, data showed that “procedures” are, by far, the most frequently remedial actions either proposed by the AIBs as safety recommendations (around 62%) or as autonomous action taken by the concerned actors (around 52%).

SR	Nr.
Procedures - Operation	180
Procedures - Compliance (regulations/legislation)	127
Procedures - Other	59
Procedures - Study/review	40
Procedures - Port and terminal facilities	37
Procedures - Information dissemination	33
Procedures - Inspection, maintenance & audit	30
Procedures - VTS	25
Procedures - Emergency	20
Procedures - Meteorological services	6
Procedures - Training	4
Procedures - Company/Owner support	4
Procedures - Search and rescue	3
Procedures - Pilot	2
Procedures - Manning	2
Procedures - Documentation	2
Procedures - Shore support	1
Grand Total	**575**

Table 51 – Safety Recommandations relevant to procedures

[33] IMO, https://www.imo.org/en/OurWork/HumanElement/Pages/ISMCode.aspx

AT	Nr.
Procedures - Operation	83
Procedures - Compliance (regulations/legislation)	35
Procedures - Other	23
Procedures - Information dissemination	15
Procedures - Port and terminal facilities	15
Procedures - Study/review	14
Procedures - Inspection, maintenance & audit	5
Procedures - VTS	4
Procedures - Emergency	4
Procedures - Meteorological services	2
Grand Total	**200**

Table 52 – Action Taken relevant to procedures

It is not surprising that procedures were widely considered safety measures since they could be effective and easily implemented in several situations.

However, EMCIP data suggested that procedures, being static tools, may be problematic in some circumstances. The safety issues concerning the voluntary deactivation of alarms on equipment like BNWAS, ECDIS and ARPA(ref. section 5.2) were emblematic and pointed out that the crew sometimes circumvented the procedures detailed in the SMS to perform other critical activities, *e.g*. negotiating the port approach manoeuvre with the pilot., It appeared that circumventing procedures for certain activities was sometimes instrumental to properly applying the procedures ruling other critical tasks. The role of procedures as reported in EMCIP brought a dual effect. On the one hand, they were perceived as a safety barrier, whose deactivation may have contributed to accidents. On the other hand, procedures may have been written in a way that it was difficult, or even impossible, to be implemented by the sharp-end operators under dynamic and challenging circumstances. The latter finding suggested that, rather than blaming the seafarers' abilities and (un)willingness to follow the procedures, a critical look at the procedures' performance during the unfolding events leading to the accident will enrich the detection of the latent safety issues.

> When deviation from procedure is identified as the 'cause' of an accident, the underlying assumption is that procedures would have prevented the accident if only they were followed. Procedures become safety measures that can be put into effect… Safety procedures might be effective in some situations and for some tasks when they are allowed to be short, very specific and a tool for remembering what to do in which sequence and by whom. However… safety procedures cannot describe all situations and, additionally, the safety procedure deals with various kinds of risk at the same time. This often causes the procedures to be either over- or underspecified and very unclear in communicating their purpose. Furthermore, the procedures as barriers are likely to be put in place where they are not effective because they are easy to implement. In order for safety procedures to be effective, it is necessary to take a new and critical look at how they are created and for what purpose and to be aware of the functional limits of procedures

Danish Marine Accident Investigation Board (2016) *Proceduralizing marine safety - Procedures in accident causation*

Appendix A Methodology

The EMSA methodology for analysis EMCIP data comprises the following 6 high-level steps[34]:

Step 1: Definition of the scope of the analysis

Setting up a clear scope, *i.e.* the area of interest of the analysis, is pivotal for the overall development of the study for designing the relevant EMCIP queries that are instrumental to the extraction of the raw dataset and the following analysis of data.

The scope of the analysis was the detection of potential safety issues concerning navigation accidents reported in EMCIP, comprising collisions, groundings and contacts involving passenger ships, cargo vessels and service ships.

The analysis encompassed the timeframe between 17/06/2011-31/12/2021 and the relevant dataset included 8,800 occurrences under the scope of the AID, either investigated or not.

The following table includes the definitions used for classifying and consolidating their severity based on the relevant legal instruments.

[34] The methodology has been applied to other analysis conducted on fishing vessels, Ro-Ro vessels and container vessels and it is available at http://emsa.europa.eu/implementation-tasks/accident-investigation.html.

Severity values for the analysis	Taxonomy values (attribute "Occurrence severity")	Definition
VS (Very Serious)	Very Serious	A **very serious** marine casualty means a marine casualty involving the total loss of the ship or a death or severe damage to the environment (Res. MSC.255(84), Ch.2.22)
OMC (Other Marine Casualties)	Serious Less serious	**Serious** casualties. are casualties to ships which do not qualify as very serious casualties. and which involve a fire, explosion, collision, grounding, contact, heavy weather damage, ice damage, hull cracking, or suspected hull defect, *etc*., resulting in: ▪ immobilization of main engines, extensive accommodation damage, severe structural damage, such as • penetration of the hull under water, etc., rendering the ship unfit to proceed*, or ▪ pollution (regardless of quantity); and/or ▪ a breakdown necessitating towage or shore assistance. **Less serious** casualties. are casualties to ships which do not qualify as very serious casualties or serious casualties (MSC-MEPC.3/Circ.3)
MI (Marine Incident)	Marine Incident	A **marine incident** means an event, or sequence of events, other than a marine casualty, which has occurred directly in connection with the operations of a ship that endangered, or, if not corrected, would endanger the safety of the ship, its occupants or any other person or the environment. (Res. MSC.255(84), Ch.2.10)

Table 53–Data mapping and definitions for occurrence severity

Step 2: Definition of Safety Areas (SA)

SA represent areas of interest identified on the basis of the attributes that are available in EMCIP *e.g*. vessel types or size, events which are the manifestation of the casualty (*i.e*. the casualty event), operational modes of the vessel, or any other attribute from the taxonomy provided that enough data is available for analysis.

SA derived by combining specific attributes of the taxonomy and have been linked to the potential safety issues to offer a higher informative value.

For this analysis, SA derives by grouping specific values of casualty events for "Occurrences with ships" (OWS) reported in EMCIP. OWS are unwanted event in which there was some kind of energy release with impact on the ship, its cargo or the environment (*e.g*., fire, collision, grounding *etc*.).

Definitions were taken from EMCIP operational guidelines agreed with the MS. This approach had the advantage to ensure a proper categorization in line with the current EMCIP reporting scheme.

The definitions used for the SA based on casualty events linked to navigation accidents, either directly or indirectly, are included in the tables below. The column "Taxonomy values" shows the values of the EMCIP taxonomy used for the data consolidation into SA.

SA (Occurrences with ships)	Taxonomy values (attribute: "Occurrence with ship")	Definition
Collision	Collision > With other ship Collision > Ship not underway Collision > With multiple ships Collision	A casualty caused by ships striking or being struck by another ship, regardless of whether the ships are underway, anchored or moored. This event might involve two or more ships.
Contact	Contact > Fixed object Contact > Other Contact > Unknown Contact > Floating object Contact > Flying object Contact > Ice	Contact is a casualty caused by a ship striking or being struck by an external object, floating, fixed, or flying (the sea bottom is excluded).
Grounding	Grounding > Power Grounding > Drift Grounding/Stranding	An event during which a moving navigating ship, either under command (power), or not under command (drift), strikes the sea bottom, shore or underwater wrecks.

Table 54– SA encompassing casuaty events direclty linked to navigation accidents

SA (Occurrences with ships)	Taxonomy values (attribute: "Occurrence with ship")	Definition
Damage to ship or equipment	Damage to ship or equipment Hull failure	Damage to equipment, system or the ship not covered by any of the other casualty type, including failures affecting the general structural strength of the ship.
Fire/explosion	Fire Explosion Fire/Explosion	An uncontrolled ignition of flammable chemicals and other materials on board of a ship. Fire is the uncontrolled process of combustion characterised by heat or smoke or flame or any combination of these. An explosion is an uncontrolled release of energy which causes a pressure discontinuity or blast wave.
Flooding/Foundering	Flooding > Progressive Flooding > Massive Flooding Foundering	An event during which the ship is taking water on board. It can be progressive (the water enters gradually) or massive (the water flow is abrupt and considerable). Foundering refers to an event during which the ship is taking water on board and

SA (Occurrences with ships)	Taxonomy values (attribute: "Occurrence with ship")	Definition
		eventually sinks
Loss of control/containment	Loss of electrical power Loss of propulsion power Loss of directional control Loss of containment Loss of control	A total or temporary loss of the ability to operate or manoeuvre the ship, failure of electric power, or failure to contain onboard cargo or other substances. This category includes the following sub-categories: • Loss of electrical power: the loss of the electrical supply to the ship or facility • Loss of propulsion power: the loss of propulsion because of machinery failure • Loss of directional control: the loss of the ability to steer the ship Loss of containment: an accidental spill or damage or loss of cargo or other substances carried on board a ship
Listing/Capsizing	Capsizing Listing	An event during which the ship no longer floats in the right-side-up mode due to: negative initial stability (negative metacentric height), or transversal shift of the centre of gravity, or the impact of external forces. Capsizing refers to a tipped over ship until being disabled, whereas listing concerns a ship with a permanent heel or angle of loll.

Table 55– SA encompassing casuaty events indireclty linked to navigation accidents

An occurrence may encompass one or more SA, depending on the reconstruction of the chain of the events, as shown in the example below.

A vessel collided with another ship and, following the hull breach, floodwater started to flow in, jeopardising the vessel's stability. Eventually, the vessel ran aground.

The chain of events in EMCIP should present four consequential SA:

Figure 16 - Example of a chain of events

Step 3: Identification of potential safety issues)

For each SA, as defined in the previous section, the potential safety issues have been identified through the analysis of Contributing Factors (CF) and Accident events (AE).

Unlike the previous step, only investigated occurrences were considered to identify safety issues and get the full picture, accident events and contributing factors reported from both ongoing and finished investigations with valid data were considered (351 cases[35]).

As per AI Directive, all very serious occurrences – meaning the ones with the most severe consequences – have to be investigated, while for the other occurrences the decision to investigate includes an assessment by the AIB of their importance in terms of potential lessons learned; therefore, if investigated, these occurrences have already been assessed as significant.

According to its definition[36], a safety issue encompasses one or more CF and/or other unsafe conditions. To proceed with the analysis, the CFs of the investigations reported in EMCIP have been mapped into homogenous categories to form the safety issue.

For the present analysis 9 safety issues were identified, based on the description of CF, their codification in EMCIP as well as the professional judgement of the analysts. When the description was unclear or missing, the CF coding or the AE description were used as complementary items to decide the classification to a safety issue.

The following table provides additional context to the safety issues' categorization:

SI	Definition
Competence and skills	It relates to the levels of training, skills and familiarisation acquired by the involved persons. Inadequate training or insufficient skills of a key person involved in the accident will be subject to this category.
Emergency response	It concerns the processes or actions made during an emergency status as well as the availability of the safety equipment or safety mechanisms that are used during an emergency and may include their operation or existence on board a vessel. An example would be the appropriateness of the actions carried out to suppress a fire in the engine room. The absence of a bilge alarm or the insufficient existence of life-saving appliances would also belong to this group of safety issues.
Environment	It relates to natural phenomena (external environment) or unexpected conditions of the working environment (internal environment). Strong wind, tidal effects, reduced visibility and the social environment on board would be classified here.
Organisational Factors	It stands directly to the managerial domain of the vessel, the company and other organizational system behind various entities *e.g*. port authorities, VTS services *etc*. Low manning, insufficient promotion of safety, availability of operational information, plans and procedures and other critical resources are considered under this category.
Individual factors	The focus is on issues that have to do with the status (physical or psychological) of a person involved, affecting the human decisions, performance or actions. For example, the consumption of alcohol,

[35] This number includes the investigations that at the time of the extraction were finished and ongoing.
[36]Annex to IMO Res.A.1075(28).

SI	Definition
	fatigue or psychological factors that affect the performance of a person will be classified here.
Operation planning	It relates to the failed planning and decision-making process to manage specific situation, *e.g*. passage planning or the anchorage selection.
Risk assessment	The main subject concerns safety or risk assessment, mostly situational, and its conclusions; it may include non-compliance, inadequacy or non-conduction of such an assessment. An inappropriate evaluation on the environment impact or an incomplete risk identification when approaching shallow waters would be under this category.
Work/operation methods	It relates to the processes and the ways they are carried out on board the vessel. The way the bridge is manned on the night shift, the external communications with nearby vessels or VTS, the use of navigation equipment are some examples of factors that would be classified here.
Tools and hardware (design or operation)	It relates to the design or operation of the vessel or certain of her equipment or tools used on board. The poor bridge layout or low performance design of alarms are some of the possible examples for this safety issue.

Table 56: SI and their definitions

It should be noted that a contributing factor may be attributed to more than one safety issue. This is due to the fact that safety issues may sometimes even be related among them or have certain logical links. Such a possibility is dependent especially on the particular characteristics of the vessel type, operation and company/managerial status and policies.

The approach taken for the analysis was to keep the maximum cohesion with the data reported in EMCIP by the investigator (with the exception of missing or inconsistent data), therefore, a great effort was put to link each contributing factor only to one safety issue that was more obviously related to, without making assumptions for possible additional safety issues, unless clearly mentioned in the contributing factor description or coding by the AIB.

Investigation reports were occasionally consulted when data reported in EMCIP was not sufficiently clear to detect the relevant safety issues.

Step 4: Ranking safety issues

To optimise resources, the potential safety issues detected in the previous step could be ranked, thus focusing the subsequent analysis on the critical ones in a cost-effective way.

Given the significant information available in EMCIP, no ranking has been performed and all the safety issues have been further analysed.

Step 5: Analysis

Once the critical safety issues have been identified, the analysis considered the investigation data reported in EMCIP that contained such safety issues and, consequently, analysed in detail the information encoded in the relevant attributes providing the factors that contributed to the occurrences.

The contributing factors associated to each safety issue have been combined into homogeneous categories (so-called “Areas of Concern” - AoC) to better explain the characteristics of the parent safety issue.

For instance, the CF associated to the safety issue “Tools and hardware(design/operation) have been combined in 3 AoC: (i) Equipment failure, (ii) Equipment design/ergonomics, and (iii) Bridge ergonomics.

The exercise also analysed the SR issued by the AIB and the AT by the relevant stakeholders to address the remedial actions and to reinforce the safety barriers.

Step 6: Consolidation

The analysis report should provide the conclusions of the data analysis. Thiscould be shared with stakeholders, in particular National authorities, the EU Commission and the industry for raising awareness and proposing follow-up actions as appropriate.

Appendix B EMCIP: an overview

EMCIP was established based on the provisions of article 17 of the European Directive 2009/18/EC, to serve the Member States and the Commission as an electronic database to store and provide data for analysis and interface amongst them. Thus, EMCIP can be accessed by the Commission and EMSA as well as the Member States' (and EFTA) investigative bodies and entitled authorities.

EU and EFTA Member States have an obligation to store all data on marine casualties and incidents in EMCIP. To achieve this, a number of specific information has to be inserted in the platform37.

The minimum data stored on EMCIP per occurrence, provide the requested information according to the mandatory notification data requested in Annex II of the AI Directive and the definitions provided by Resolution MSC.255 (84) of the IMO, Resolution A.1075(28) and MSC-MEPC.3 Circular 3, as amended. Moreover, a complementary taxonomy of data has been created by EMSA to facilitate the reporting and the layout presentation of each occurrence inserted in the platform. The taxonomy comprises a series of attributes that provide a certain standard of details available for use and analysis, in terms of safety investigations and safety reports or case studies, based on the input of the investigative bodies or other entitled authorities of the Member States involved in the reporting of marine casualties.

It should be also mentioned here, that EMCIP in its current version divides the occurrences into 2 main categories since the context and the codification of these categories is quite particular and deserves separate analysis:

- "**Occurrence with ship(s)**": the casualty includes damage to the vessel or her equipment and infrastructure. The characteristic attribute of this category for the sake of this study is the "casualty event", which may take values such as flooding, foundering, fire, damage to ship, *etc*.

- "**Occurrence with person(s)**": the casualty is a sole manifestation of human action (deviation) with consequences only for persons. The characteristic attribute of this category is the "deviation", that is defined as the categorization of the last event differing from the normal and leading to the accident. Deviation may take values such as slipping, falling, loss of control, *etc*.

The analysis carried out within the investigation should be reported in EMCIP in line with the ECFA model. This is an organised approach aiming at assisting the verification of causal chains and event sequences leading to a casualty and providing a structure for integrating investigation findings.

The ECFA model links in a logical and consistent way casualty events, accident events and contributing factors as defined by the IMO Res.A.1075(28) "Guidelines to assist investigators in the implementation of the casualty Investigation Code":

Casualty Event	The marine casualty or marine incident, or one of a number of connected marine casualties and/or marine incidents forming the overall occurrence (*e.g*. a fire leading to a loss of propulsion leading to a grounding).
Accident Event	An event that is assessed to be inappropriate and significant in the sequence of events that led to the marine casualty or marine incident (*e.g*. human erroneous action, equipment failure).
Contributing factor	A condition that may have contributed to an accident event or worsened its consequence (*e.g*. man/machine interaction, inadequate illumination).

The next diagram summarises an application of the ECFA model to the analysis of an occurrence where a ship ran aground following an engine failure (1 ship involved):

[37]Data reported in EMCIP can be amended, at any time, by the relevant data providers.

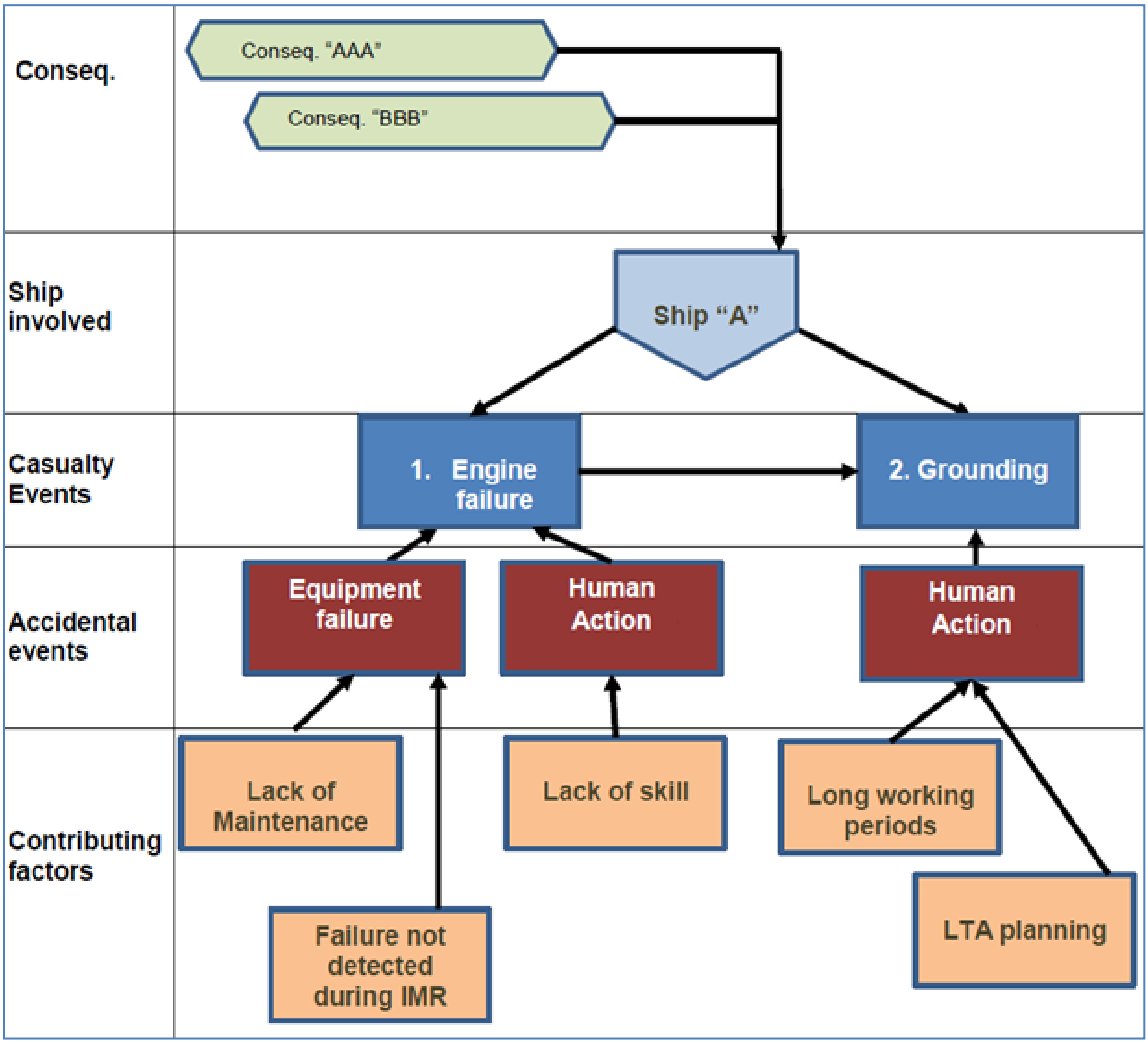

Figure 17 - ECFA diagram (1 ship involved)

In the taxonomy, Accident events have been classified as follows:

- **Equipment failure**

  A system module (subsystem) or component that does not function as intended due to some sort of breakdown. Loss of function may also be the result of operating outside the specified performance criteria (*e.g*. overload, overcapacity).

- **Hazardous material**

  Critical events associated with the presence of explosive, flammable or toxic material, where the main sources are cargo and fuel.

- **Human action**

  Operator performs in conflict with intended procedures or in a less than adequate way. Main forms are omission, commission, wrong timing or wrong sequence.

- **External agent or ship**

  This group should apply to external influences; for instance, lack of, or inadequate, support from other ships, agents or infrastructure.

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